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TRW

AUAMP Resolution Issues Techical Report

1 April 1992

Prepared Under
Contract N00014-91-D-0287

for the
Office of Naval Research
Department of the Navy
Washington, DC 20363-5000

TRW Systems Division
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Office of Naval Research Detachment
Stennis Space Center, MS 39529-5004

Attention: Mr. Ed Chaika

Subject: AUAMP Technical Issues Technical Report

Reference: (a) N00014-91-D-0287/001

Gentlemen:

The enclosed document provides an investigation into sampling intervals used in the Advanced Underwater Modeling Project (AUAMP version 2.6). This document is in response to Subtask 2 of Delivery Order #1 of the referenced contract. This document is CDRL AOO2 for the referenced task.

Sincerely,

D. O. Drew
ASW Project
TRW Systems Division
Systems Integration Group

Enclosure: (1) "AUAMP Resolution Issues Technical Report" 1 April 1992.

cc: Defense Technical Information Center (2)
Naval Research Laboratory (Director)
ONR Contracting Office (Code 1513) (M. Kurzius)

Statement A per telecon Ed Chaika
ONR/Code 124A
Stennis Space Center, MS 39529-5004

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1.0 INTRODUCTION

1.1 Overview

This document describes the methodology and results of a sensitivity analysis conducted on the Advanced Underwater Acoustic Modeling Project (AUAMP) transmission loss (TL) calculation. The sensitivity of the TL calculation to range-dependent environmental input parameters and to the model's internal sampling interval was investigated. The model's output transmission loss is analyzed because AUAMP signal excess predictions are ultimately based on calculated TL. In addition, range-dependent environmental data is used directly only in the TL calculation. Reverberation and noise predictions are made using the AUAMP transmission loss calculation as well. The range-dependent environmental data consists of sound velocity profile (SVP), bottom depth, bottom type, and sediment thickness. All TL calculations were made using AUAMP version 2.6.

Table 1 summarizes the two primary objectives of this task. The first goal of this analysis was to determine whether the two nautical mile sampling interval currently employed by AUAMP is adequate to represent the transmission loss structure in all shallow water environments. The two nautical mile sampling interval dictates how often the transmission loss function is evaluated as a function of range and is independent of any data base resolution. The effect of the sampling interval is a complex function dependent on the transmission loss function itself, the database resolutions and the variability of each of the four environmental parameters as a function of range. The second goal involved determining the general sensitivity of the AUAMP transmission loss output to each of the four range-dependent parameters for a specific sampling interval and data base grid resolution. This analysis attempted to quantify which environmental parameter has the greatest effect on the transmission loss given a set sampling interval and data base resolution. The analysis documented in this paper was performed with AUAMP runs exclusively; no comparison with measured data was performed. Thus, the observations made

are preliminary, pending confirmation with real data. Real data comparisons are planned for later analysis.

1.	Definition of the modeled range resolution necessary to accurately represent the TL structure as a function of each of the four input environmental parameters used by the ASTRAL TL model.
2.	Definition of the sensitivity of AUAMP version 2.6 TL output at a constant sampling interval to each of the range-dependent parameters.

Table 1. Tasks Addressed in this Document

This document is the first of five technical reports which review the applicability of the Advanced Underwater Modeling Project (AUAMP) for shallow water predictions. The second technical report to be completed under this investigation will be a compendium of shallow water data bases, models and experiments. The third document will present actual measured data compared with AUAMP predictions using internal data bases as well as in-situ environmental data. The fourth document will attempt to determine the source of any discrepancy between measured and modeled data. This first technical report will assist future work in determining if the difference between measured and modeled data is due to sampling intervals and database resolutions or model algorithms. The fifth technical report summarizes the entire investigation.

1.2 Organization of Document

The remainder of this document is divided into three sections. Section 2.0 presents an overview of AUAMP and its internal range-dependent data bases. Section 3.0 presents the methodology used for analysis of sampling intervals and input environmental data resolution. Finally, section 4.0 presents preliminary observations based on work-to-date.

2.0 AUAMP OVERVIEW

2.1 AUAMP Capabilities

AUAMP is a system of models which calculates range-dependent transmission loss, reverberation, and noise. Using these estimates and input system Figure of Merit (FOM) parameters, signal excess is estimated for frequencies from 20 to 1000 Hz. AUAMP is constructed of four constituent sub-models: transmission loss (ASERT); reverberation (REVERB); noise (ANDES); and signal excess (SYSMOD). After the completion of each submodel AUAMP allows output to be reviewed. The data flow of the AUAMP system is given in Figure 1.

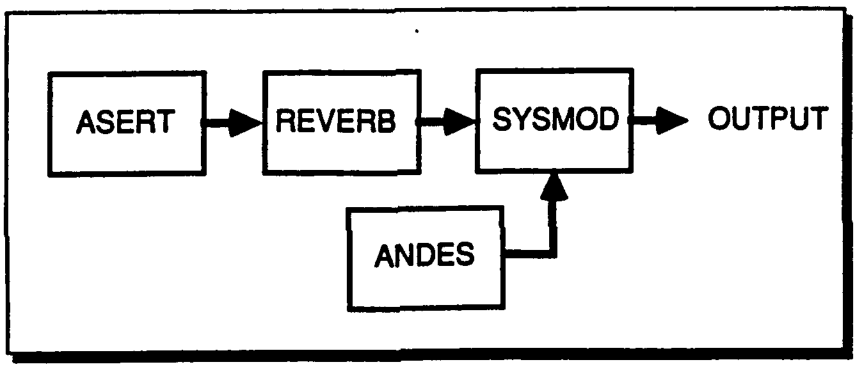


Figure 1. Data Flow of AUAMP

The primary advantage of AUAMP is its separate handling of system and environmental parameters. The first three sub-models (ASERT, REVERB, and ANDES) use data that is specific only to the ocean area of interest, no system parameters are used as input to these models. The final model, SYSMOD, integrates the system FOM parameters with the transmission loss, reverberation, and noise estimates from ASERT, REVERB and ANDES to get acoustic system performance predictions. This distinction between environmental and system parameters lends itself to computational efficiency. System or detection parameters can be altered without recalculation of environmental parameters.

Typical system performance predictions are probability of detection and signal excess as a function of range, bearing, and source, target, and receiver geometry.

The predominant calculation in AUAMP is transmission loss. The transmission loss model, ASERT, uses range-dependent CZ-ASTRAL to calculate transmission loss. It is in this module that transmission loss to seven depths of interest (surface, bottom, volume scattering depth, target and three environment specific seamount heights) is calculated. Besides providing transmission loss for source-to-target and target-to receiver, these transmission loss calculations form the basis of the reverberation calculation. Reverberation is calculated using the transmission loss output for the appropriate scatterer of interest for the appropriate ranges. The noise model ANDES uses CZ-ASTRAL independently to calculate the transmission loss from various specified noise sources in the ocean in order to determine the noise level received by the receiver. Because of the importance of the CZ-ASTRAL calculation and its effect on the signal excess computation, the effect of input environmental data on the CZ-ASTRAL transmission loss calculation is investigated directly. Environmental parameters are not directly input to the signal excess module. Therefore, the impact of environmental data on AUAMP system performance predictions correlates directly to the impact of input environmental data on the TL calculation.

2.2 Range-dependent Inputs

AUAMP version 2.6 uses the eight input environmental parameters shown in Table 2. Only the four parameters shown in Table 3 are modeled as range-dependent. The sensitivity of the transmission loss to the four range-dependent input environmental parameters is investigated in this paper.

• Windspeed • Volume Scattering Coefficient • Bottom Scattering Coefficient • Bottom Depth • Sound Velocity Profile • BLUG Province • Sediment Thickness

Table 2. Input Environmental Parameters to AUAMP

• Bottom Depth • Sound Velocity Profile • BLUG Province • Sediment Thickness

Table 3. Range-Dependent Input Environmental Parameters

The range-dependent environmental inputs are extracted by AUAMP from the Historical Ocean Profile (HOP) data bases. The resolution and name of each of the range-dependent data bases used by AUAMP is given in Table 4. Section 2.3 explains the data bases in more detail.

Environmental Parameter	Data Base Resolution	Data Base Name
BLUG Province	1/12 degree	LFBL (BLUG)
SVP	1/2 degree	SVP
Sediment Thickness	1/12 degree	LFBL (BLUG)
Bottom Depth	1/12 degree	DBDBC

Table 4. Environmental Parameters and Data Base Resolution

AUAMP currently calculates transmission loss every two nautical miles for each user specified azimuthal bearing. In addition, at each of these two nautical mile range steps AUAMP samples environmental data in the data bases. If the new environment differs significantly from the previous environment the newly extracted environmental information is used to calculate the transmission loss at that range. Table 5 states the condition for which new environmental data is used by AUAMP for the four environmental parameters. If the new information does not differ significantly, the previous environments' data is used. This is done to save time in the ASTRAL TL calculation which recomputes certain parameters based on changes in the environment. The less environmental variance, the more quickly the TL calculation is performed. It is important to note that even if the environment does not change, calculations are still performed every two nm. If the environment does change, additional calculations are done to incorporate the new data into the calculation.

Environmental Parameter	**Condition Necessary to Call a New Environment**
BLUG Province	If current BLUG province is not equal to previous BLUG province
SVP	If current SVP type is not equal to previous SVP type
Sediment thickness (measure in two way travel time (TWT))	If current TWT differs more than .3 seconds from previous TWT
Bottom Depth	If current bottom depth differs by more than 5 % from previous bottom depth

Table 5. Conditions Necessary to Call a New Environment Currently Employed by AUAMP

2.3 AUAMP Internal Data Bases

AUAMP uses four major data bases: SVP; bottom loss; sediment thickness and; bottom depth. The sound speed profile data base gives sound speed as a function of depth for the entire water column. The Low Frequency Bottom Loss (LFBL) data base, derived from the BLUG model, gives bottom loss and sediment thickness values. A set of 9 geoacoustic parameters describe the bottom type for every latitude and longitude. Shallow water areas an attenuation exponent is included for a total of 10 geoacoustic parameters. The LFBL data base is accessed through province numbers which point to a set of geoacoustic parameters. These parameters are then used in the TL calculation. Included in the LFBL data base, separate from the geoacoustic parameter set, is sediment thickness for every latitude and longitude. Sediment thickness is represented in the data base with two way travel time. The Digital Bathymetric Data Base - Confidential (DBDBC) gives the bottom depth for a specified location in the ocean.

2.4 AUAMP Range Intervals

AUAMP version 2.6 calculates transmission loss every two nm. This means that every two miles the condition shown in Table 5 is checked and the transmission loss function is evaluated. The procedures of checking the condition and calculating the transmission loss function are independent. The transmission loss function is evaluated every two nautical miles regardless of the changes in environment. If one of the conditions in Table 5 is true, then additional calculations to the normal transmission loss calculations are made. It is important to note that there is an independent relationship between sampling interval and grid resolution. The AUAMP sampling interval is used no matter what the data base grid resolution is or how the environmental changes. The objective of this task is to determine whether the two nautical mile sampling interval is sufficient to accurately represent TL and under what conditions (if any) other sampling intervals may be preferred. For example, if a finer resolved data base is being used, a two nautical mile sampling interval may not capture the environmental information as often as needed to accurately predict transmission loss.

3.0 METHODOLOGY AND RESULTS

3.1 AUAMP Sampling Intervals

The transmission loss output in AUAMP is a complex function of sampling interval and environmental data which includes range-dependent SVP, bottom type, sediment thickness and bottom depth. The range-dependence of the environmental data plays an especially complicated role in quantifying sampling interval effects. The sampling interval may have different effects on the transmission loss depending which environmental parameter is varying. In addition, how often and how drastically the environmental parameter is varying may affect how the sampling interval effects the transmission loss. To bracket the problem, several environmental data cases were defined to address each of these concerns as shown in Table 6. Frequency, source, target and receiver depths were held constant as shown in Table 7.

The environmental data sets shown in Table 6 progress from the base case to cases where one environmental parameter varies with range while the other three are held constant. Three separate data bases representing different rates of fluctuation of the environment were constructed for each of the four environmental parameters. Thus, for each shaded box in Table 6, three separate data bases were employed. The AUAMP sampling interval was then varied for each of the separate data bases for the specified environmental parameter.

The artificial data bases were constructed to perform the cases shown in Table 6 represent possible but random changes in shallow water ocean environments. Appendix A presents all the artificial data bases and the methods used to implement them. For convenience, the artificial data bases are represented on grids in nautical miles (nm) rather than minutes as in the HOP data bases. The environmental data was changed at every grid point in the appropriate data base. Thus, to represent a high degree of fluctuation in the environment for a specific parameter, a very fine grid was used.

Specific progressions of environmental data were not reflected in the artificial data bases with the exception of the bottom depth data base. The effect of these specific types of environmental progressions on the ASTRAL transmission loss is detailed in reference 5. The bottom depth artificial data base was constructed to reflect a deep to shallow water upslope environment.

Case	SVP Type	BLUG Type	Sediment Thickness (sec)	Bottom Depth (ft)	AUAMP Sampling Interval
Base	7	14	1.3	Constant at 300, 600, 1000	Varies
1	Varies with Range (3 grids)	14	1.3	Constant at 300, 600, 1000	Varies
2	7	Varies with Range (3 grids)	1.3	Constant at 300, 600, 1000	Varies
3	7	14	Varies with range (3 grids)	Constant at 300, 600, 1000	Varies
4	7	14	1.3	Varies with range (3 grids)	Varies

Table 6. Environmental Data Sets

Input Parameter	Value
Source/Receiver Depth	200 ft
Target Depth	200 ft
Frequency	300 Hz

Table 7. AUAMP Run Parameters

Section 3.1.2 through Section 3.1.6 present the environmental data sets shown in the rows of Table 6. For each section three environmental parameters were held constant while the fourth was modeled as varying. A range-independent case is presented initially to provide a base case for comparison.

- Section 3.1.2 - Range-Independent Case
- Section 3.2.2 - Range-Dependent in BLUG Province
- Section 3.2.3 - Range-Dependent in Sediment Thickness
- Section 3.3.3 - Range-Dependent in Sound Velocity Profile
- Section 3.3.4 - Range-Dependent in Bottom Depth

The environmental data sets for sediment thickness, BLUG province, and SVP type were varied over three constant bottom depths to determine the depth dependence of any sampling interval effects.

3.1.2 Range-Independent Base Case

Figures 2 through 4 give range-independent AUAMP TL runs at various sampling intervals for three bottom depths of 300, 600, and 1000 ft. These cases are presented to show the effect of the two nautical mile sampling interval on non-range-dependent data as well as to provide a base case to be used for future comparisons. Five sampling intervals of 1/2, one, two, five, and ten nautical miles were used for the following Figures. Table 6 shows the parameters used for the base case.

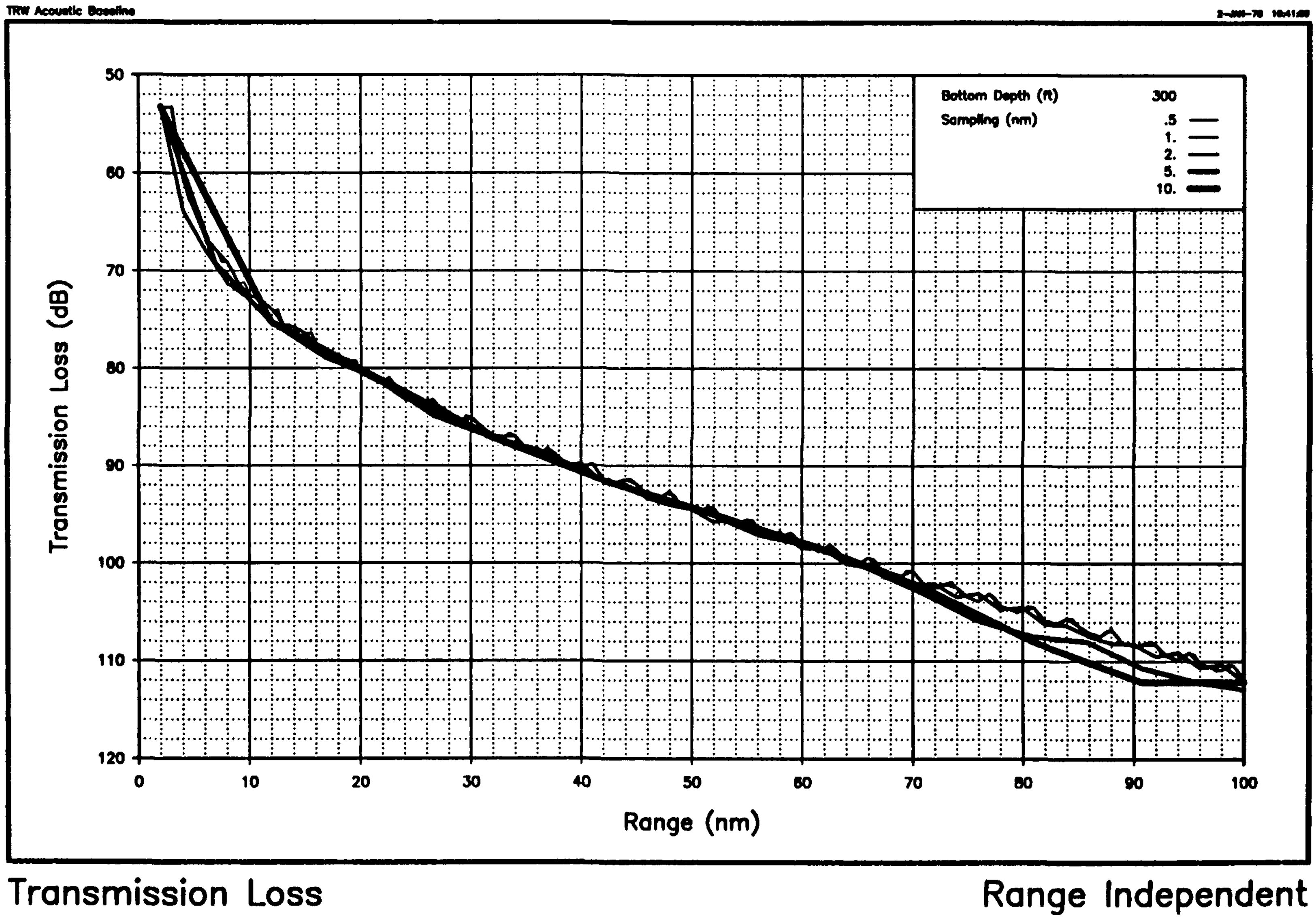


Figure 2. Effect of Varying Sampling Rates Within AUAMP, Range Independent, 300 ft Depth

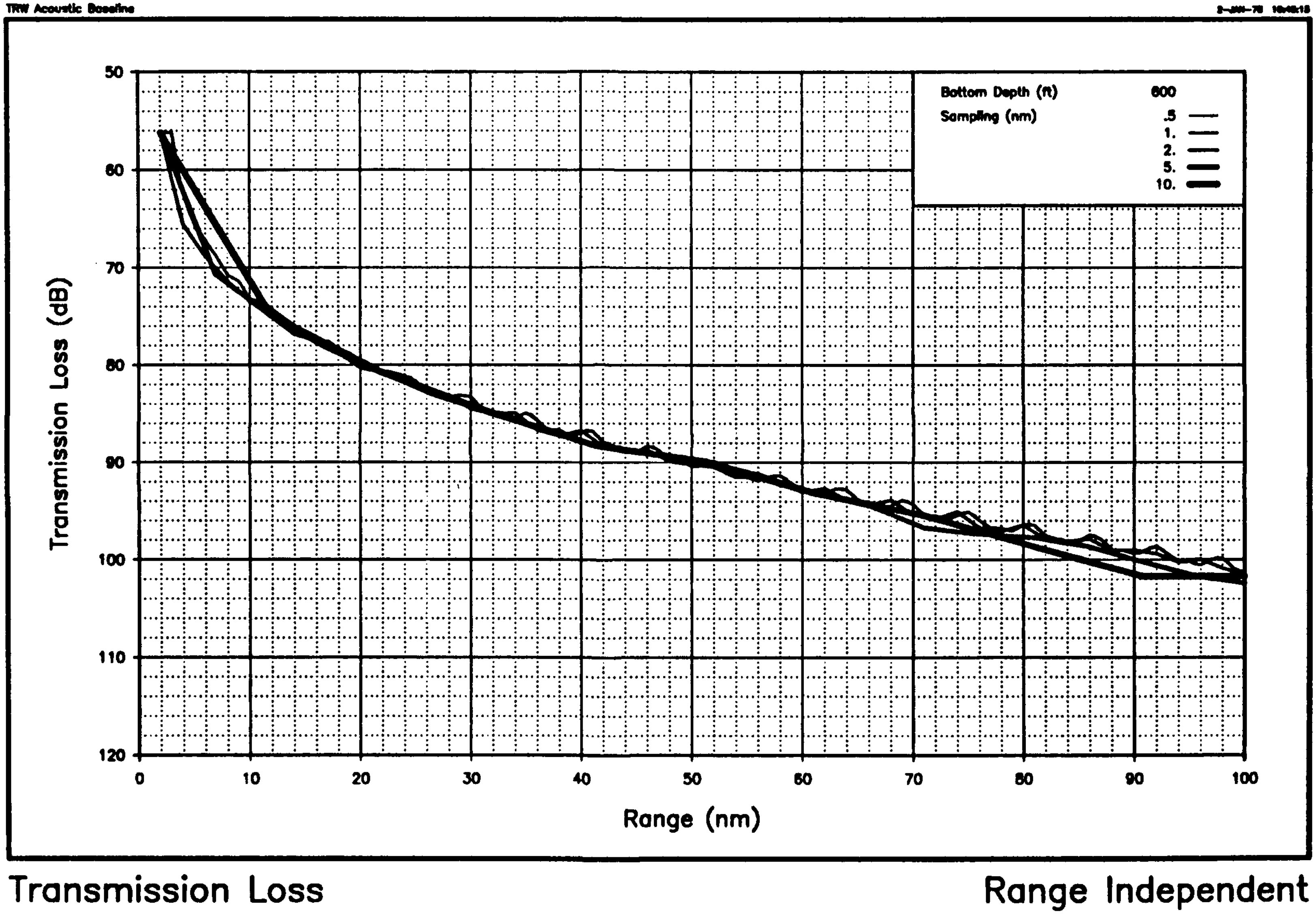


Figure 3. Effect of Varying Sampling Rates Within AUAMP, Range Independent, 600 ft Depth

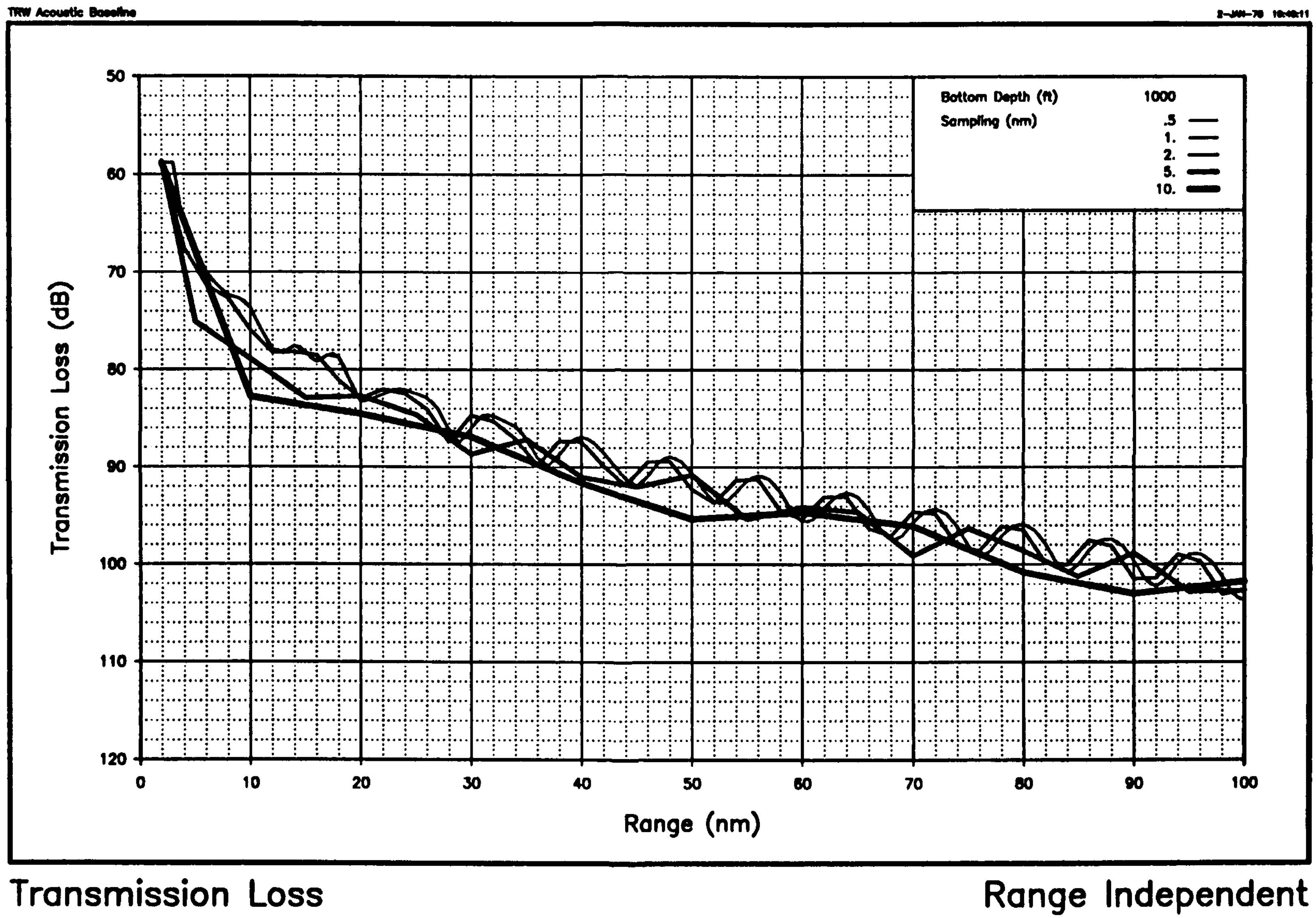


Figure 4. Effect of Varying Sampling Rates Within AUAMP, Range Independent, 1000 ft Depth

3.1.3 **Range-dependent in BLUG Province**

AUAMP TL calculations, for which sediment thickness, SVP type and bottom depth were held constant while the BLUG province was varied, were performed. Data bases were constructed with various resolutions to see the effect that different environmental fluctuation rates have on the TL calculation when coupled with different sampling intervals. AUAMP was run employing different sampling intervals on the various grid resolutions for three water depths of 300, 600, and 1000 ft. Different depths were used to note the depth dependence of the sampling interval effect on the transmission loss calculation. Table 8 gives the resolution of the artificial data bases constructed for the BLUG province study along with the AUAMP sampling intervals applied.

Environmental Parameter	Data Base Resolution (Grid) (nm)	AUAMP Sampling interval (nm)
BLUG Province	1	1/2, 1, 2
	5	1, 2, 5
	50	1, 2, 5, 10

Table 8. Ma.rix of BLUG Data Base Resolution and Sampling Interval

Figures 5 through 7 show the effects of varying the BLUG province on a one nautical mile data base grid for the three bottom depths. Figures 8 through 10 show the effect of varying the BLUG province on a five nautical mile grid. Figures 11 through 13 shown the effect of a 50 nautical mile grid.

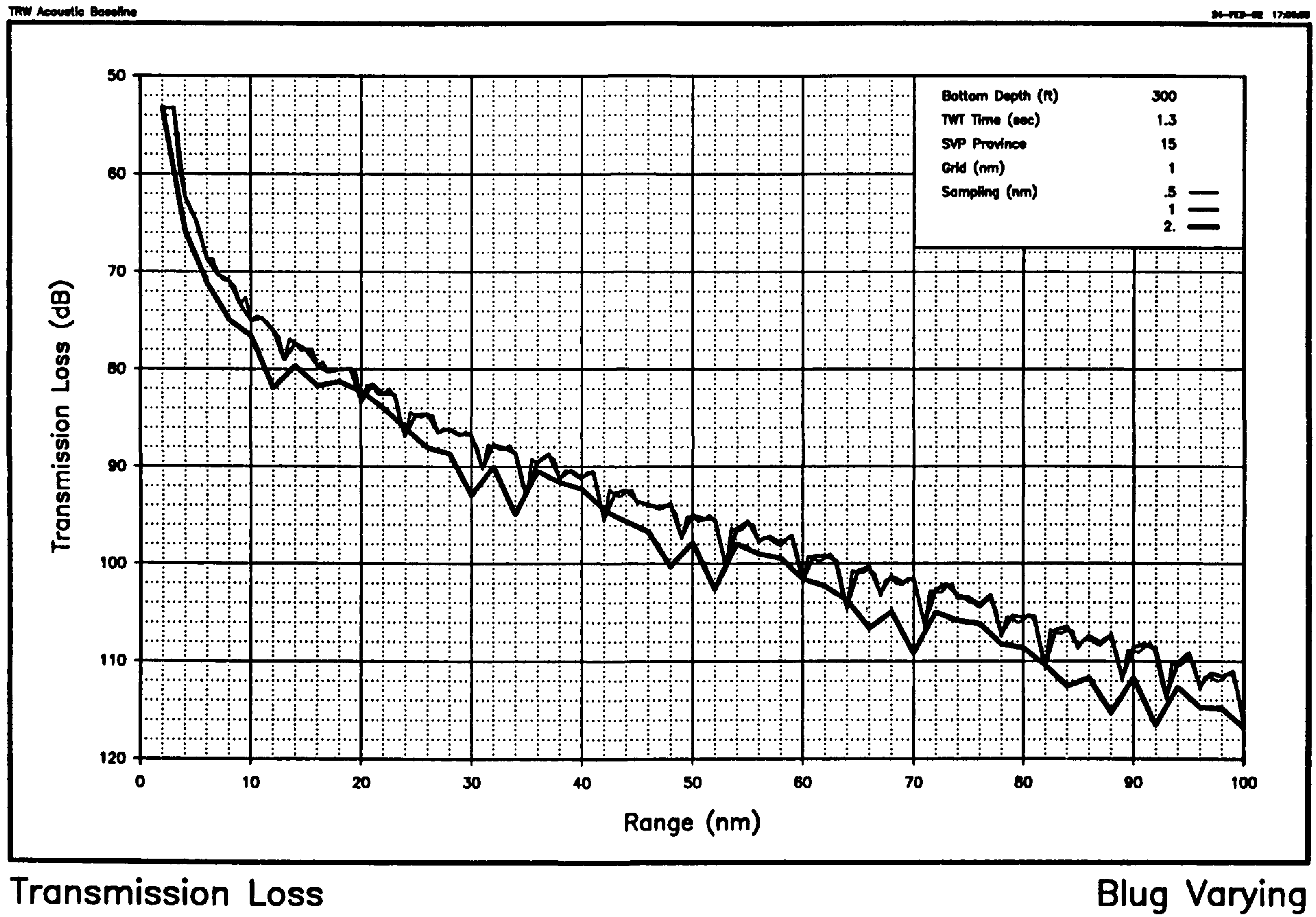


Figure 5. BLUG Province Effects, 1 nm Grid, 300 ft Depth

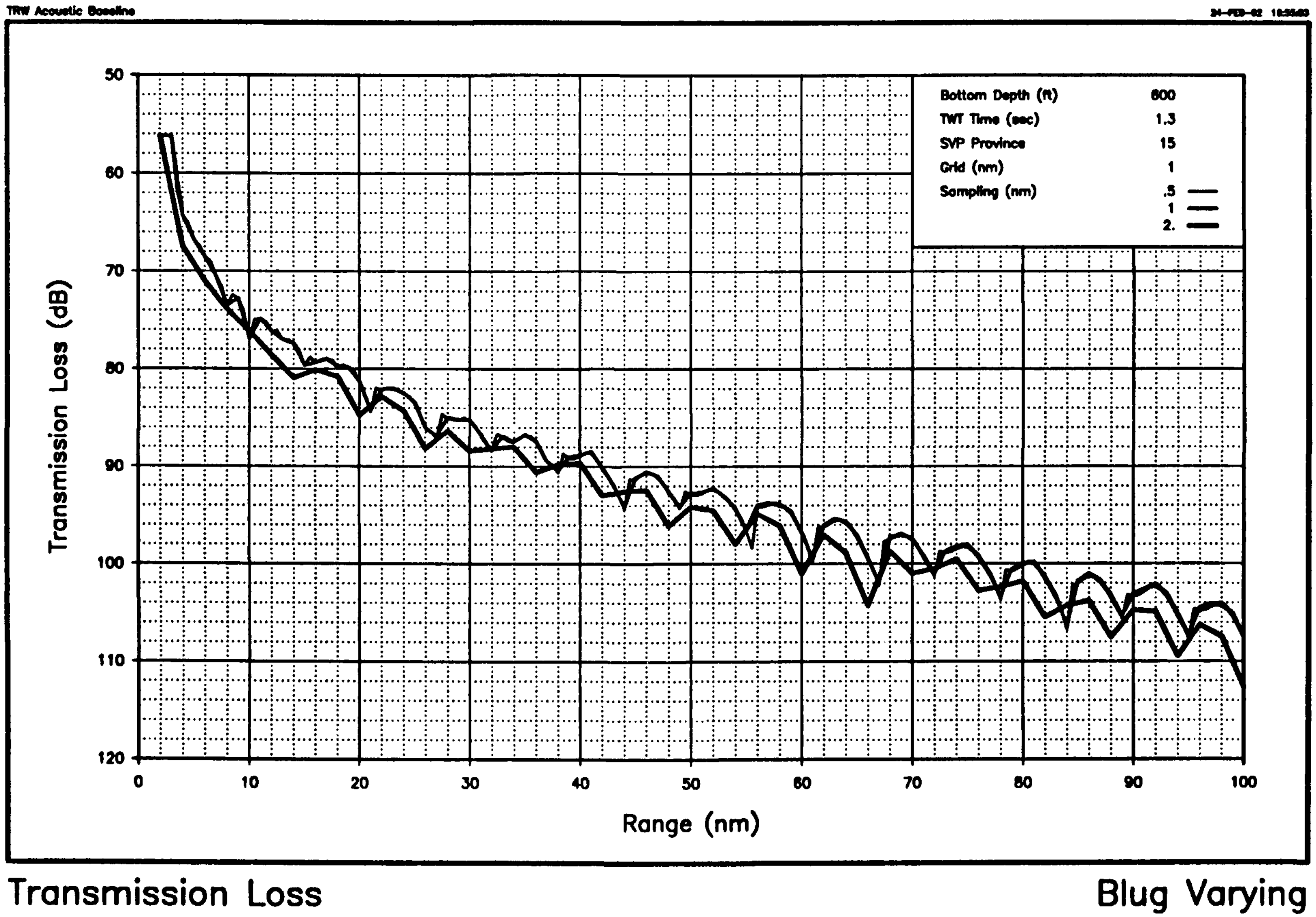


Figure 6. BLUG Province Effect, 1 nm Grid, 600 ft Depth

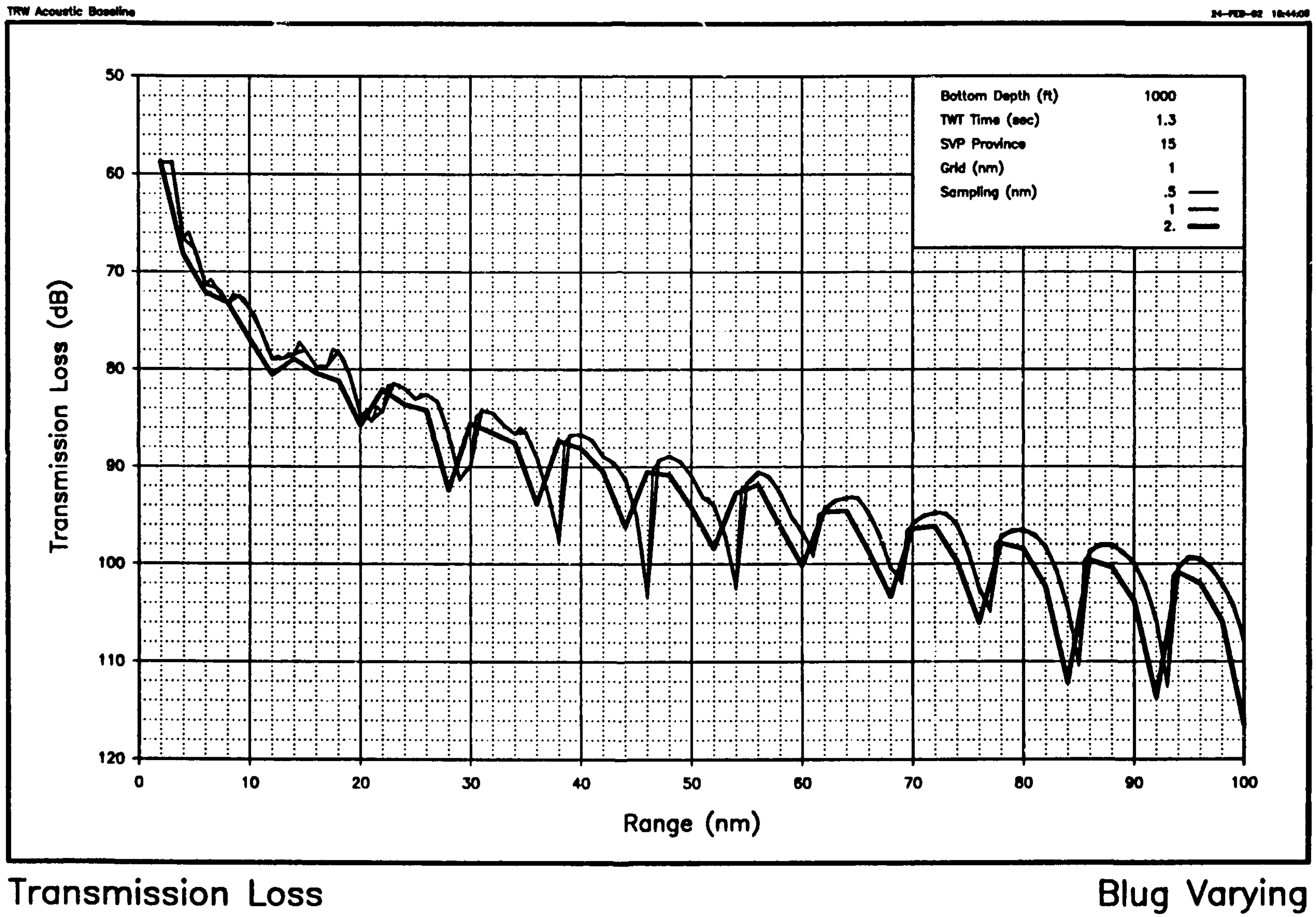


Figure 7. BLUG Province Effect, 1 nm Grid, 1000 ft Depth

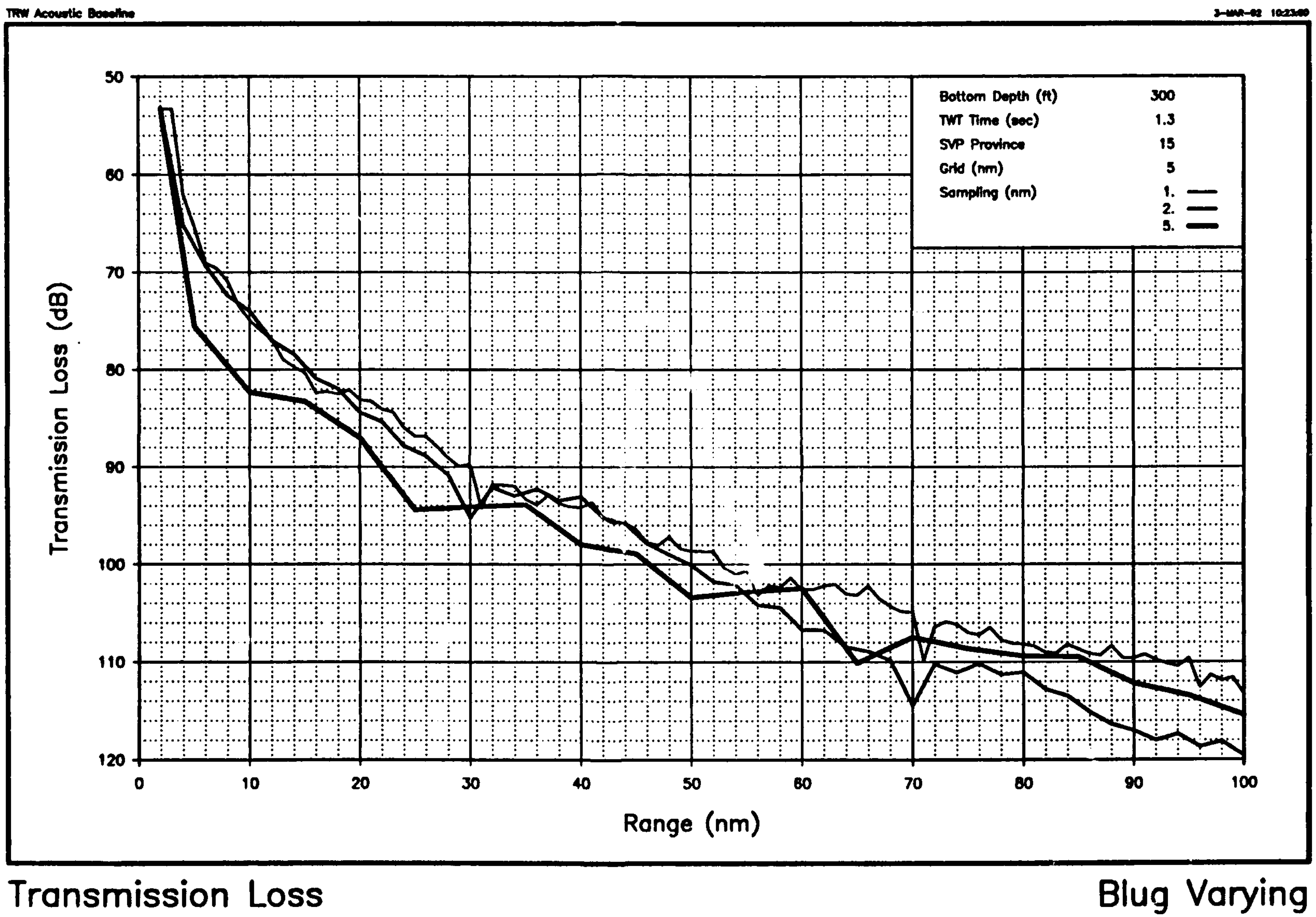


Figure 8. BLUG Province Effect, 5 nm Grid, 300 ft Depth

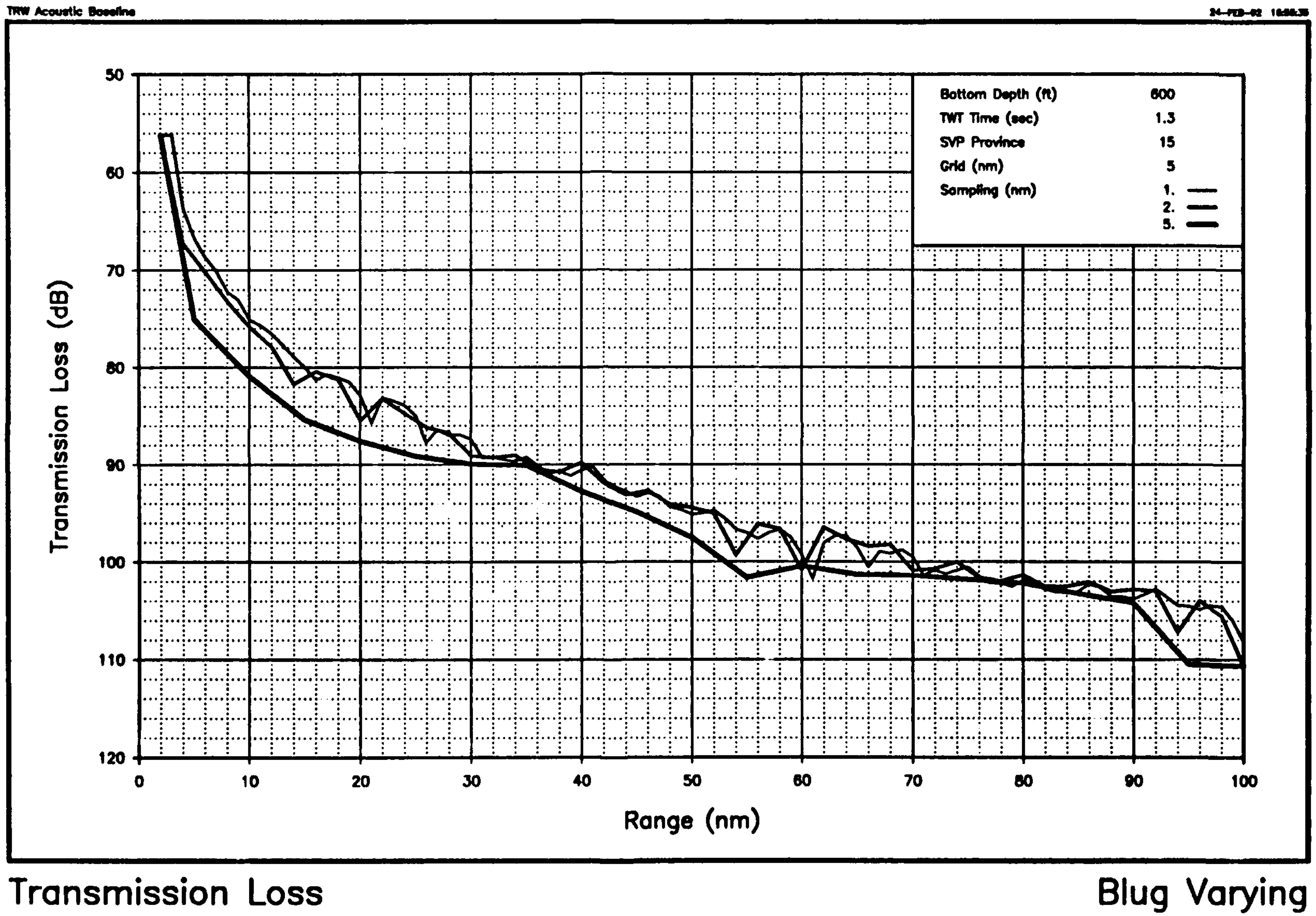


Figure 9. BLUG Province Effect, 5 nm Grid, 600 ft Depth

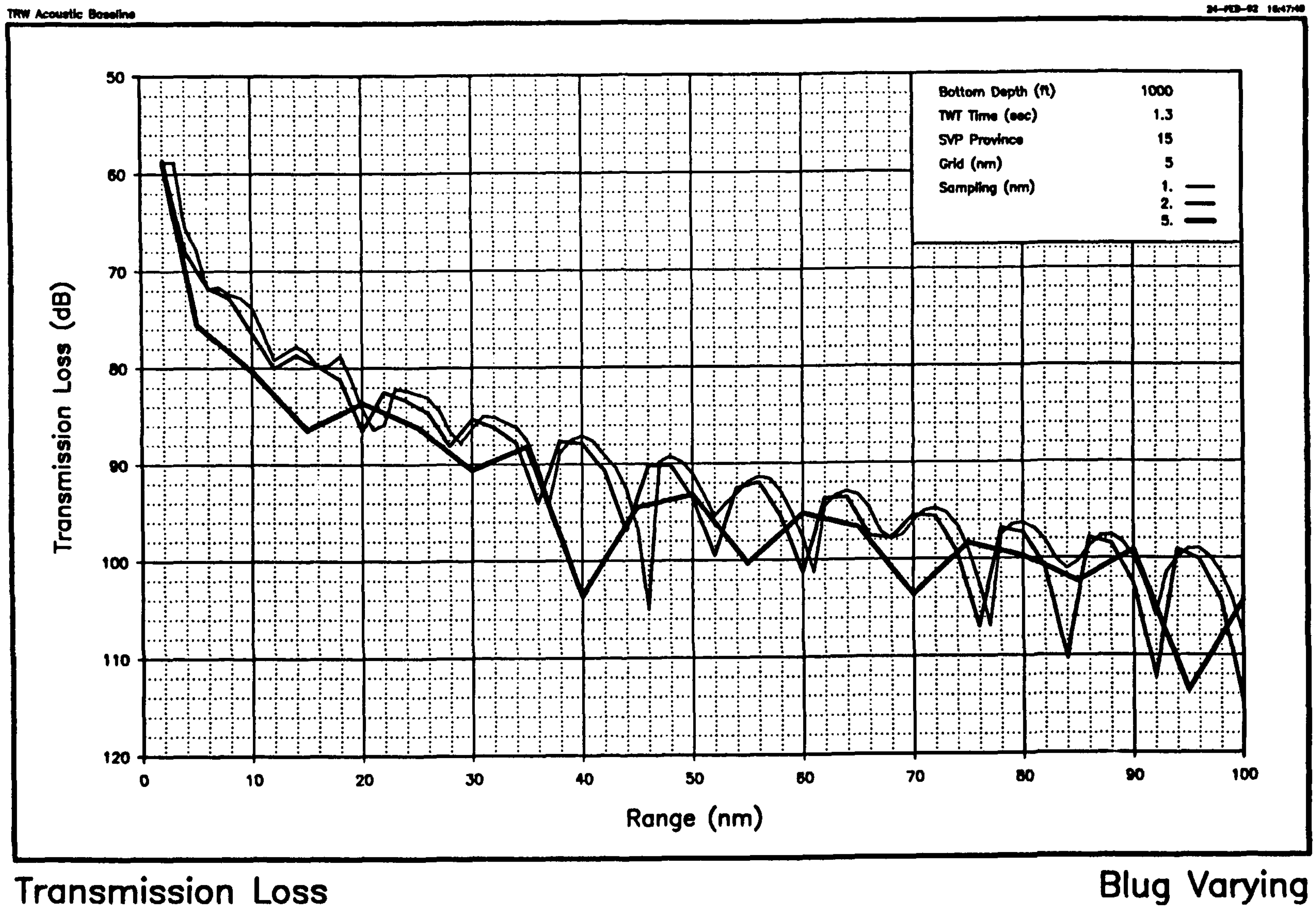


Figure 10. BLUG Province Effect, 5 nm Grid, 1000 ft Depth

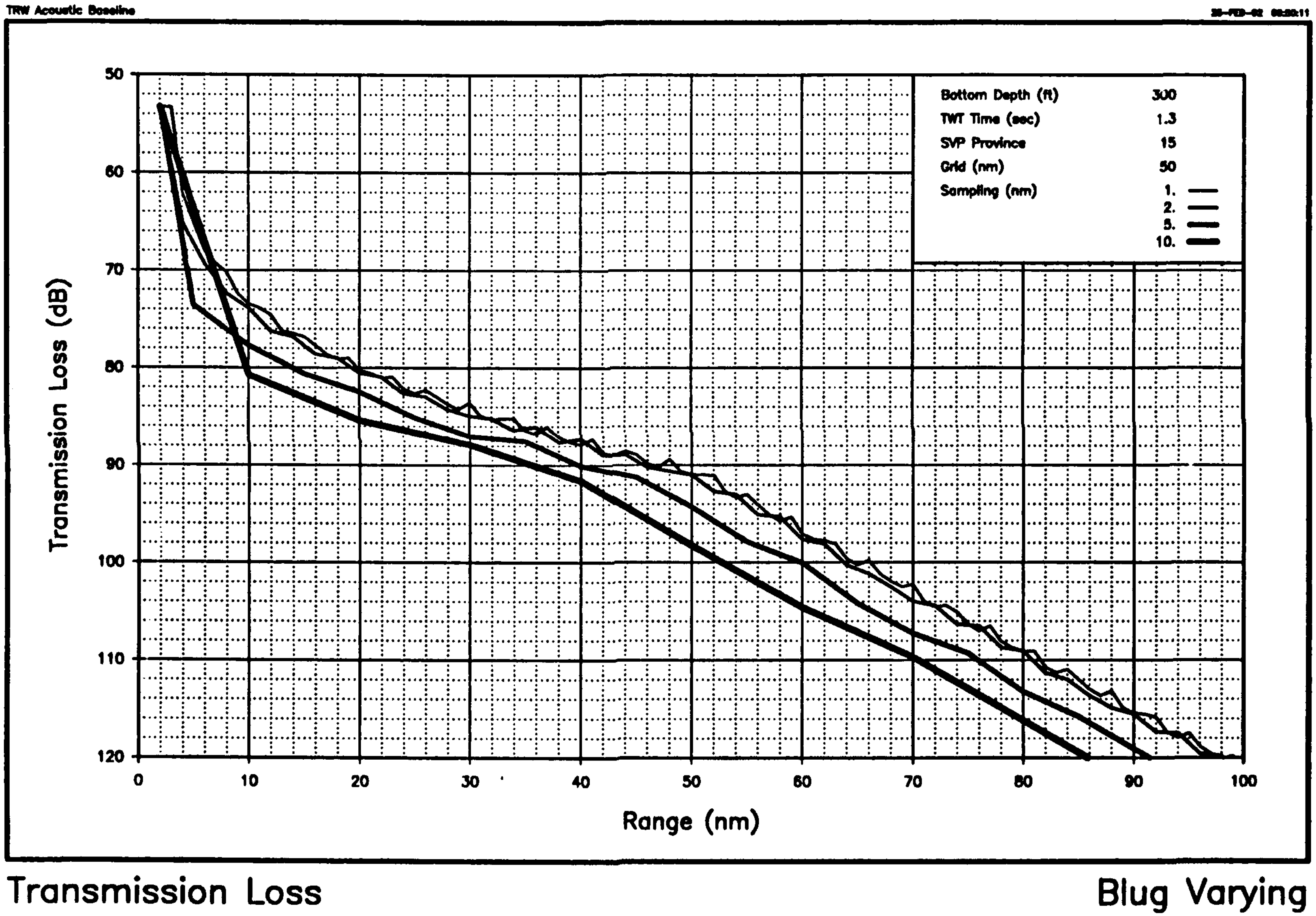


Figure 11. BLUG Province Effect, 50 nm Grid, 300 ft Depth

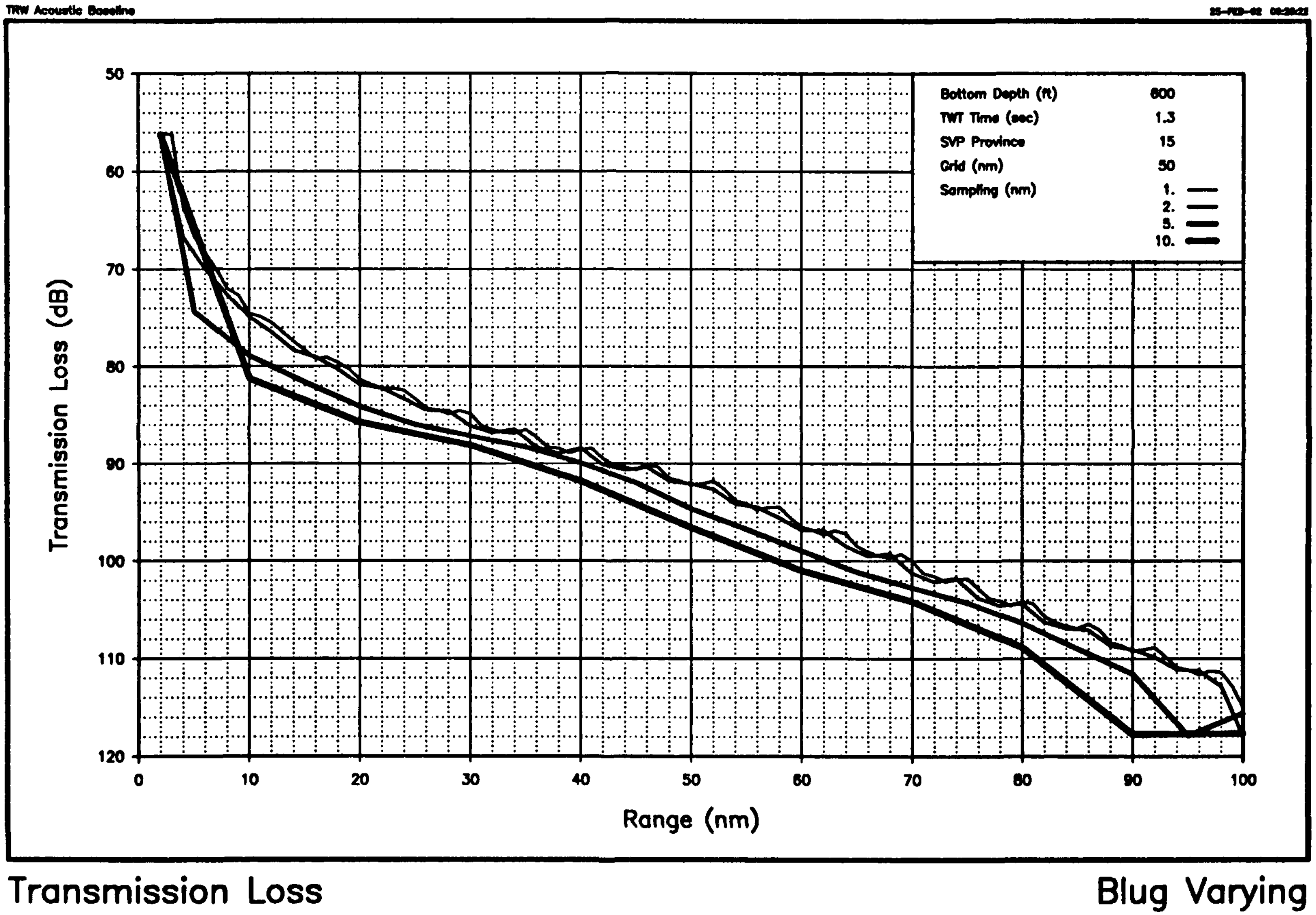


Figure 12. BLUG Province Effect, 50 nm Grid, 600 ft Depth

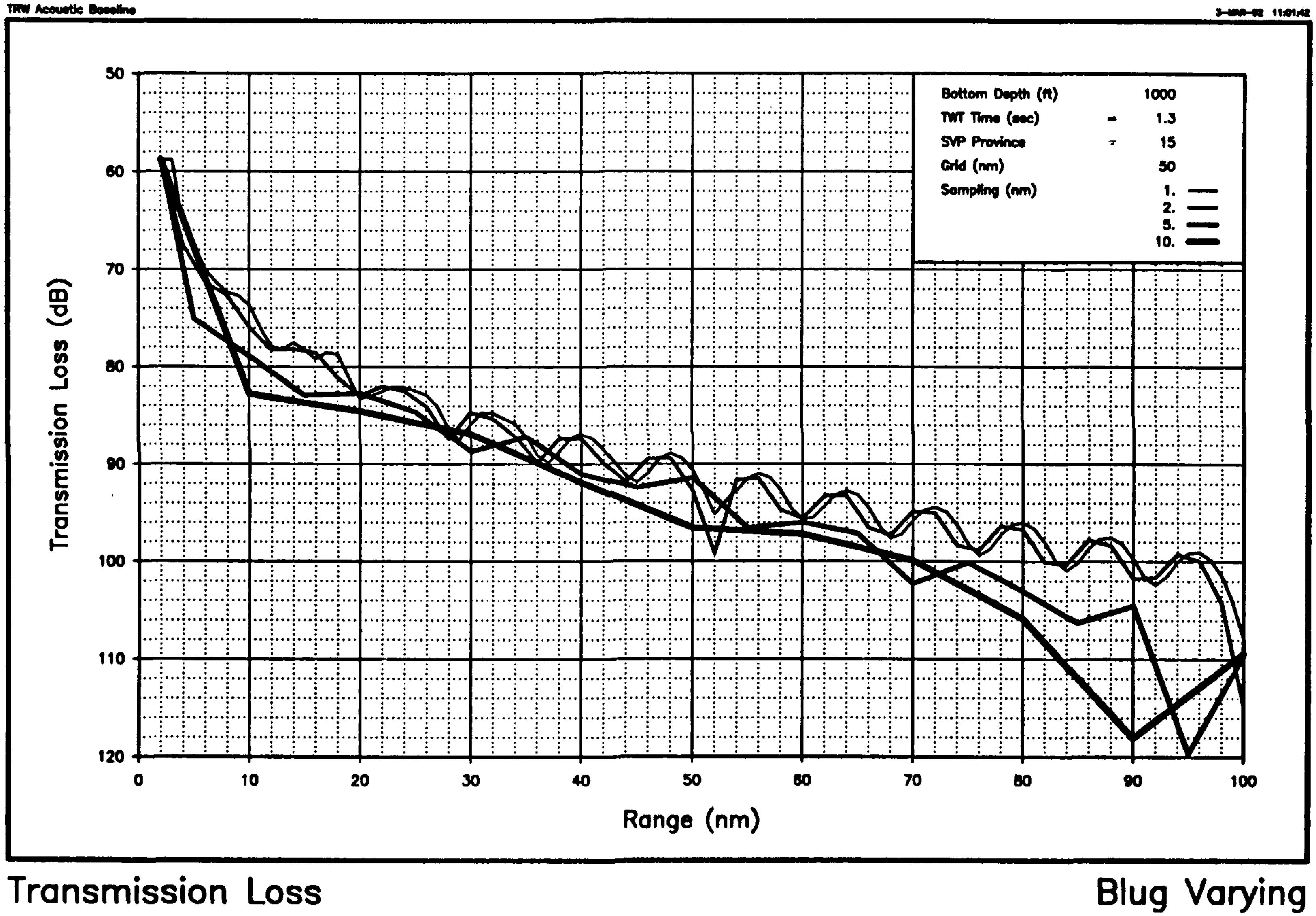


Figure 13. BLUG Province Effect, 50 nm Grid, 1000 ft Depth

3.1.4 **Range-dependent in Sediment Thickness**

AUAMP calculations, for which BLUG province, SVP type, and bottom depth were held constant while the sediment thickness was varied, were performed. Data bases were constructed with various resolutions to see the effect of environmental fluctuation rates on the TL calculation when coupled with sampling interval changes. AUAMP was run employing different sampling intervals on the various grid resolutions for three water depths of 300, 600 and 1000 ft. Table 9 gives the resolution of the artificial data bases constructed for the sediment thickness study along with the AUAMP sampling intervals applied.

Environmental Parameter	**Data Base Resolution (Grid) (nm)**	**AUAMP Sampling interval (nm)**
Sediment Thickness	1	1/2, 1, 2
	5	1, 2, 5
	50	1, 2, 5, 10

Table 9. Matrix of Sediment Thickness Data Base Resolutions and Sampling Intervals

Figures 14 through 16 show the effects of varying the sediment thickness on a one nautical mile data base grid for the three bottom depths. Figures 17 through 19 show the effect of varying the sediment thickness on a five nautical mile grid. Figures 20 through 22 show the effect of a 50 nautical mile grid.

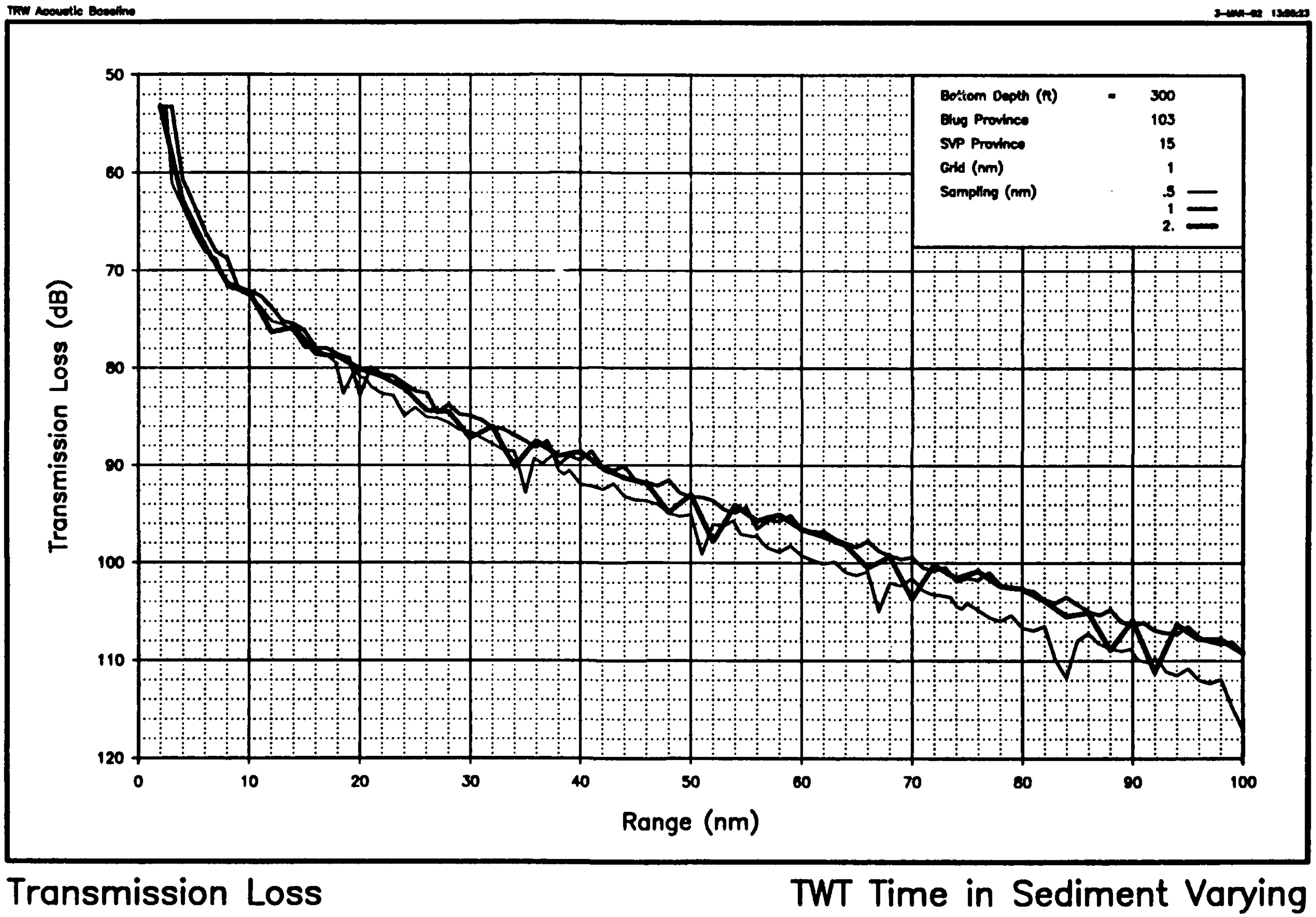


Figure 14. Sediment Thickness Effect, 1 nm Grid, 300 ft Depth

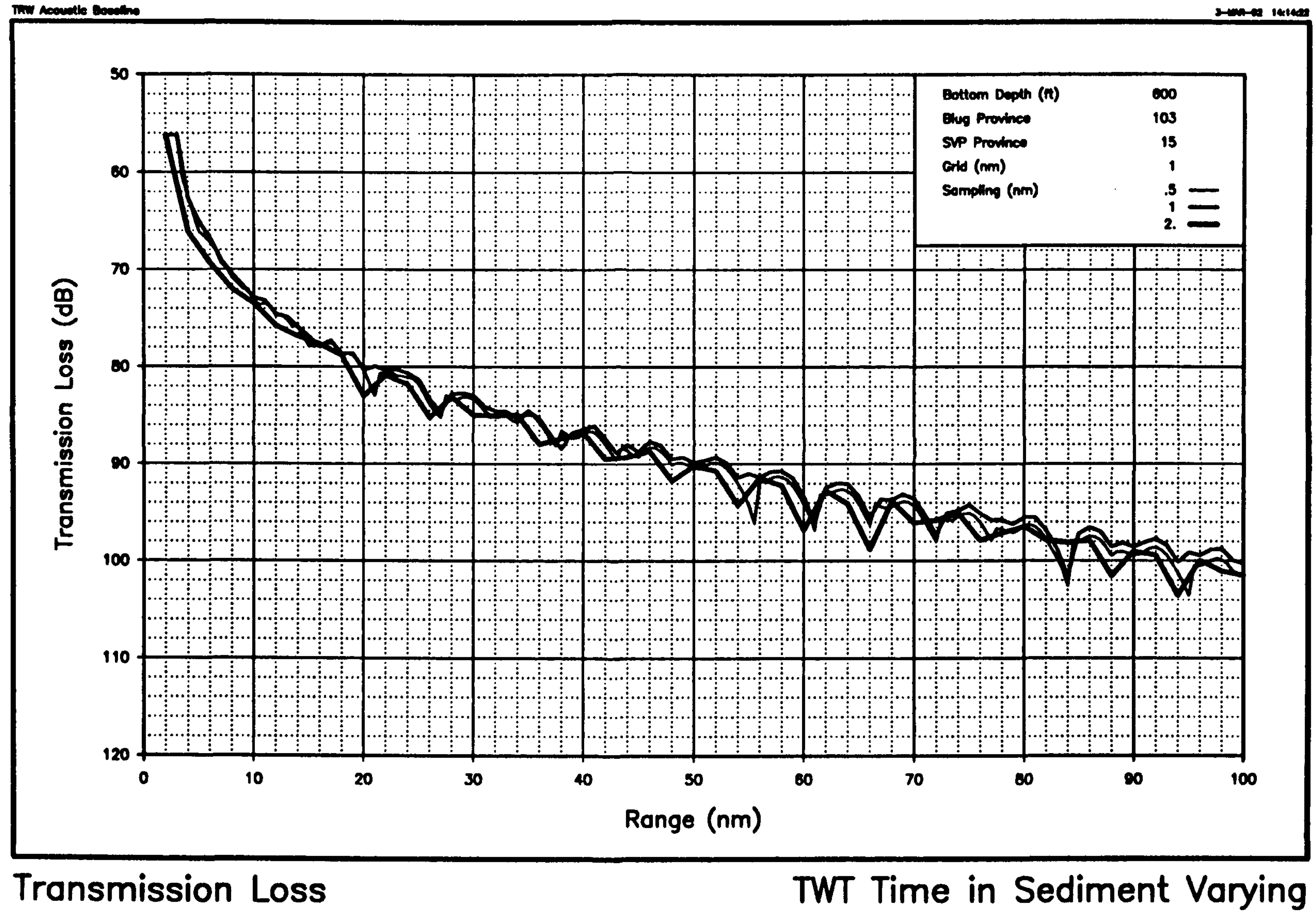


Figure 15. Sediment Thickness Effect, 1 nm Grid, 600 ft Depth

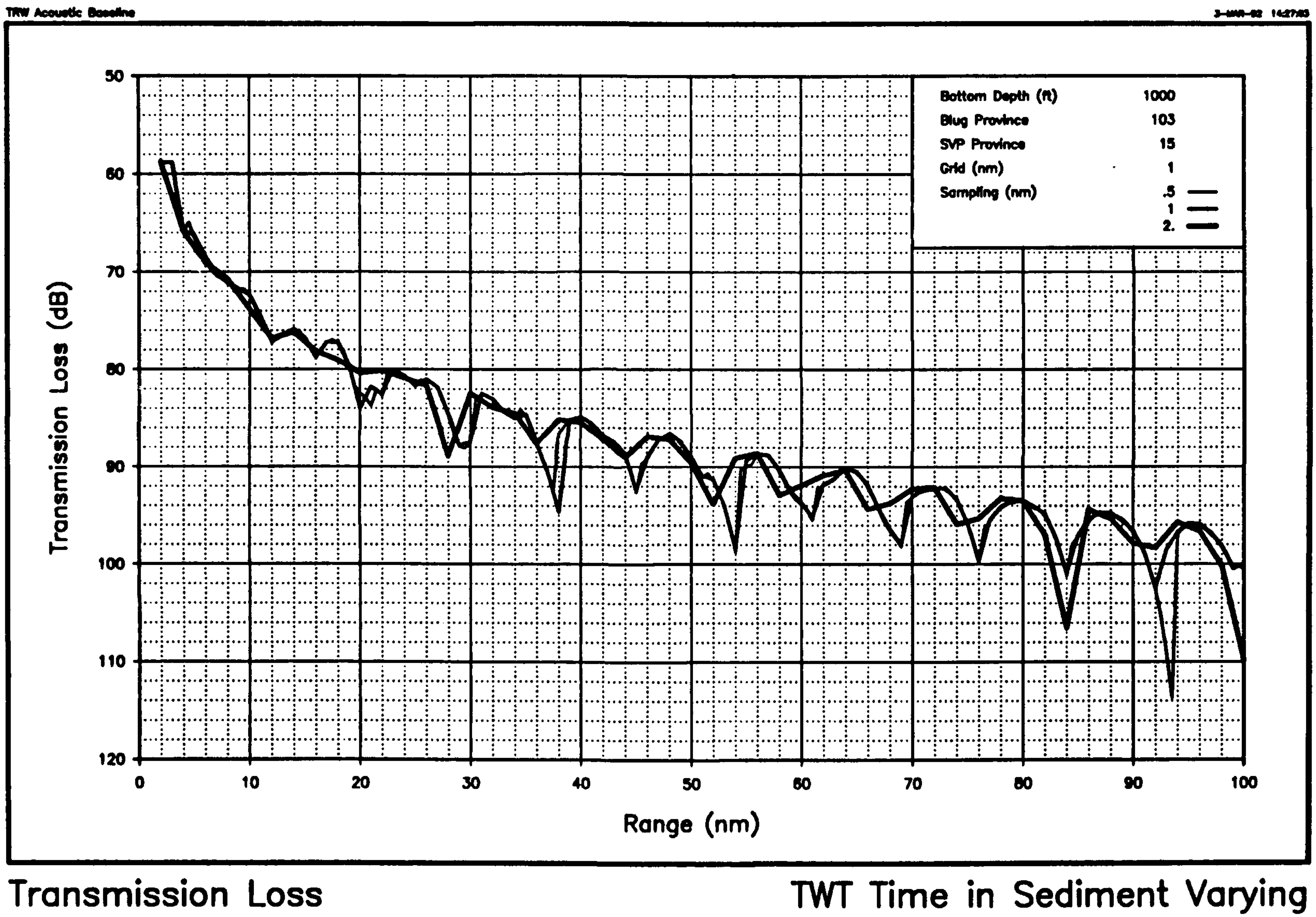


Figure 16. Sediment Thickness Effect, 1 nm Grid, 1000 ft Depth

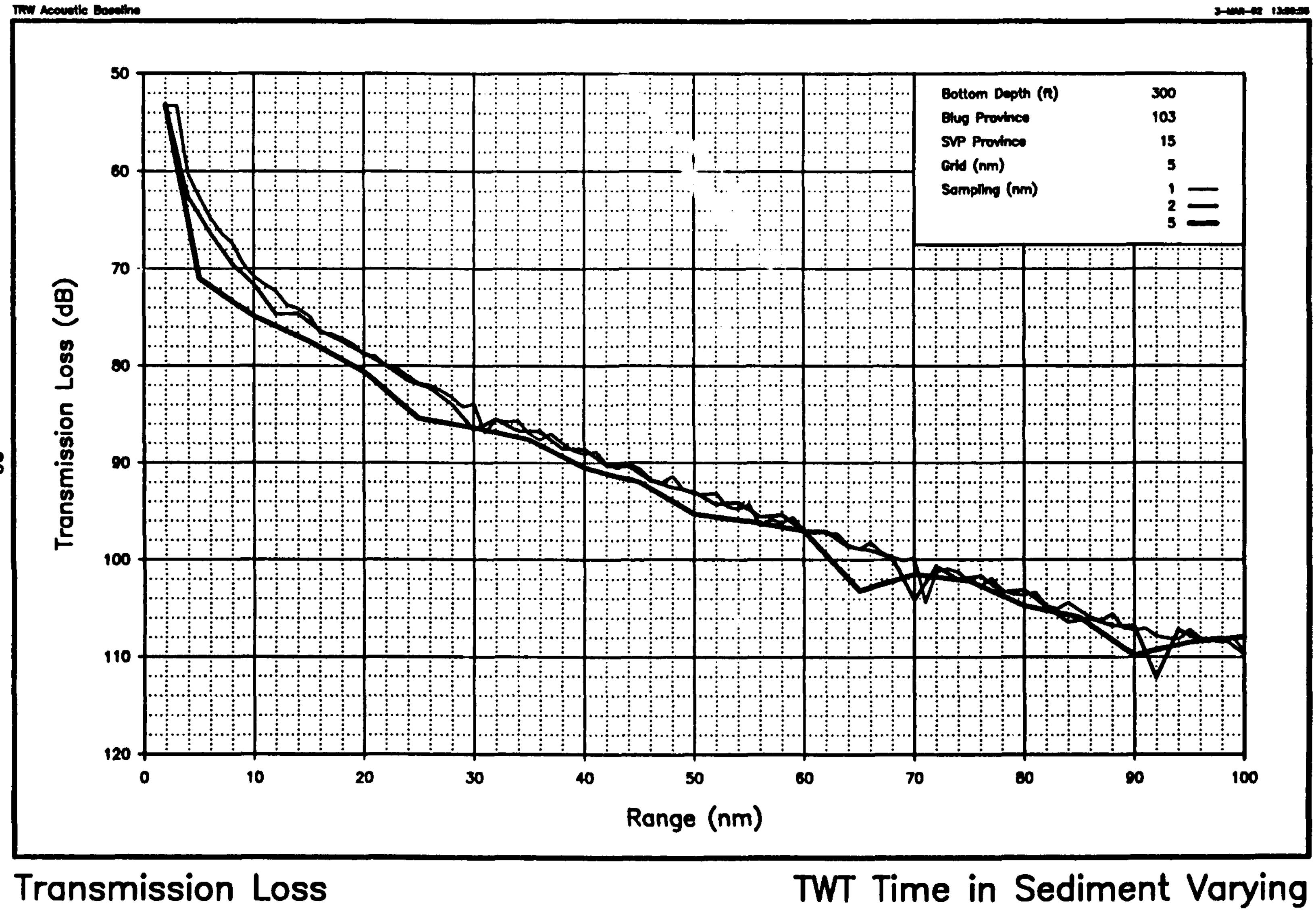


Figure 17. Sediment Thickness Effect, 5 nm Grid, 300 ft Depth

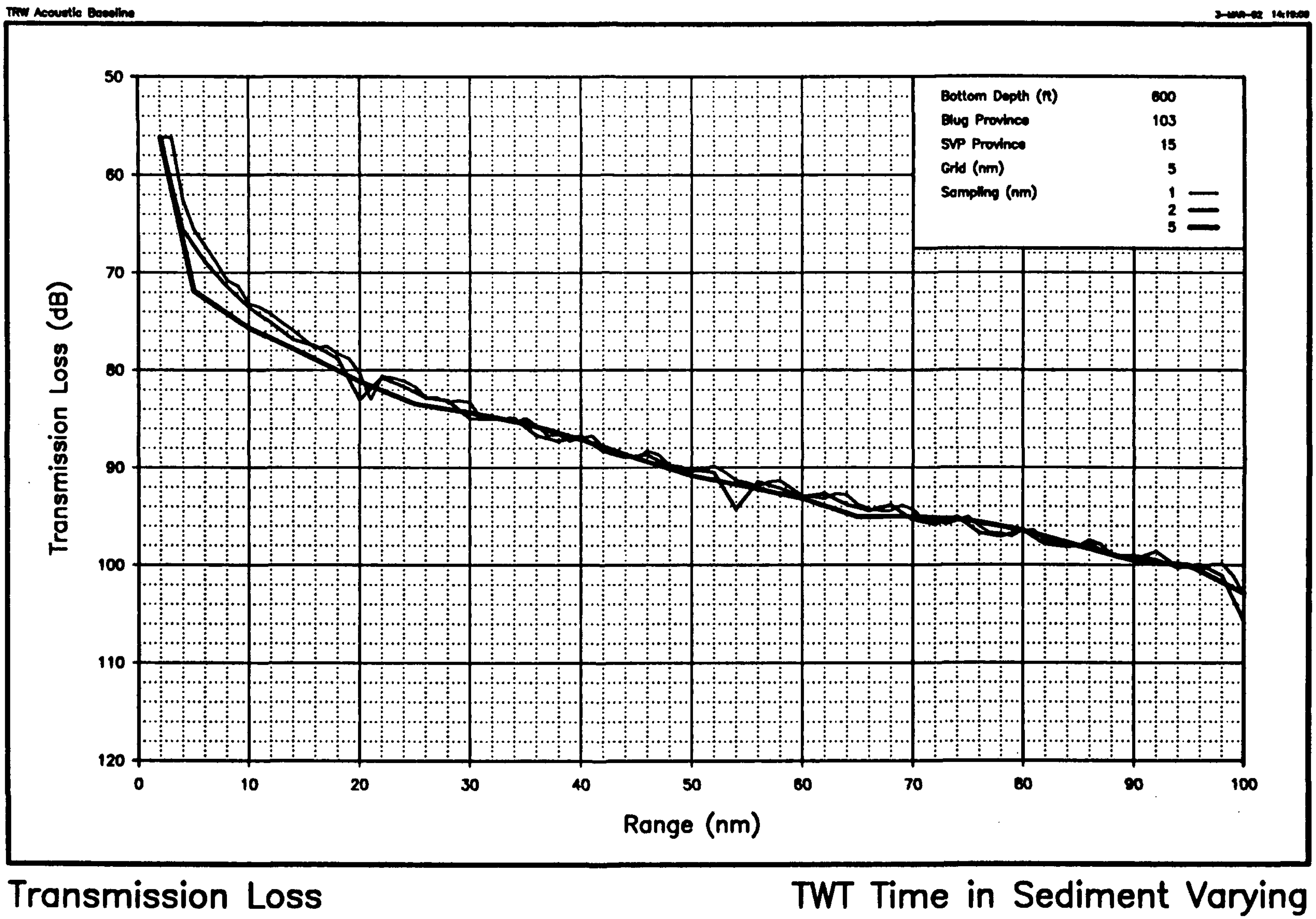


Figure 18. Sediment Thickness Effect, 5 nm Grid, 600 ft Depth

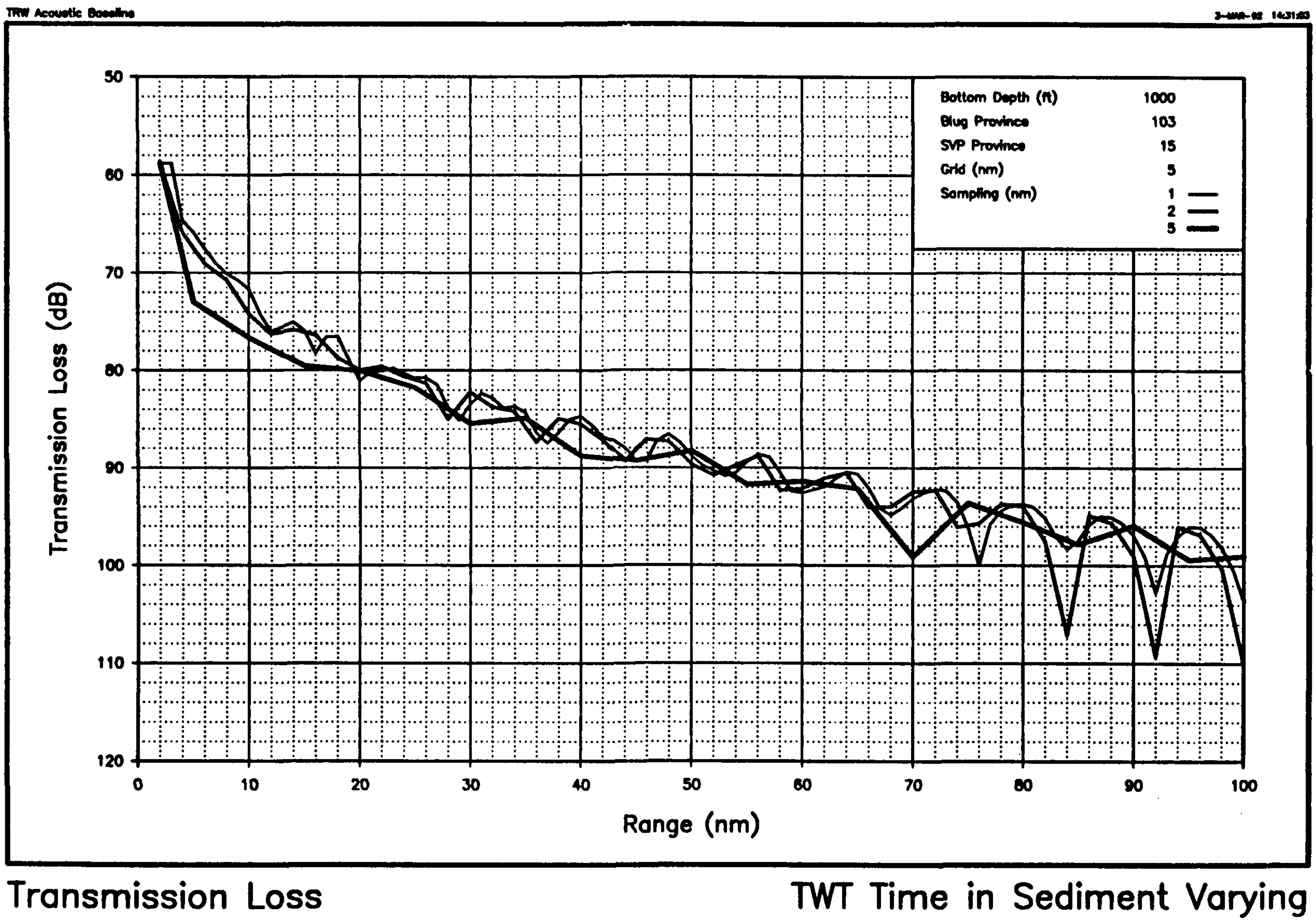


Figure 19. Sediment Thickness Effect, 5 nm Grid, 1000 ft Depth

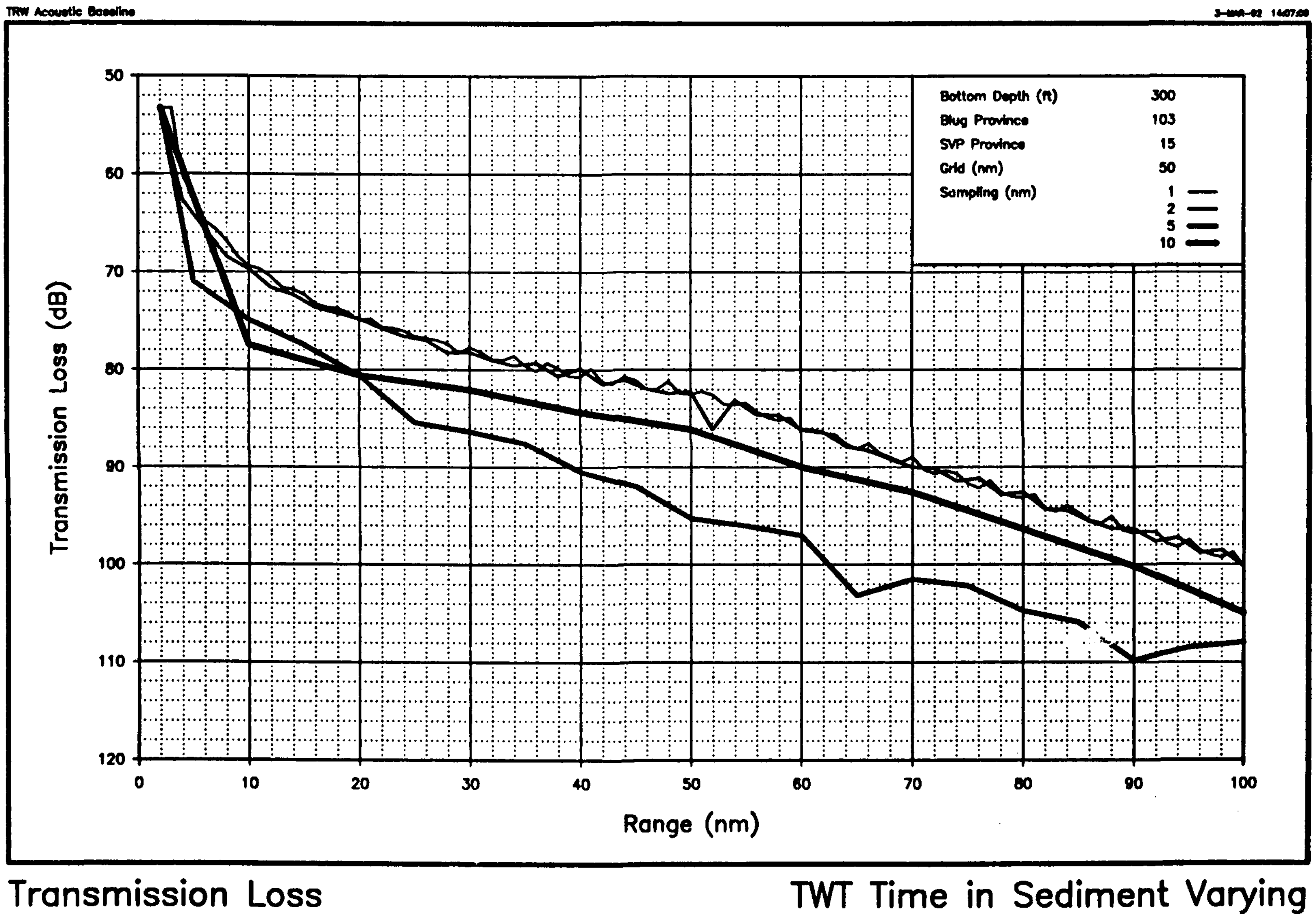


Figure 20. Sediment Thickness Effect, 50 nm Grid, 300 ft Depth

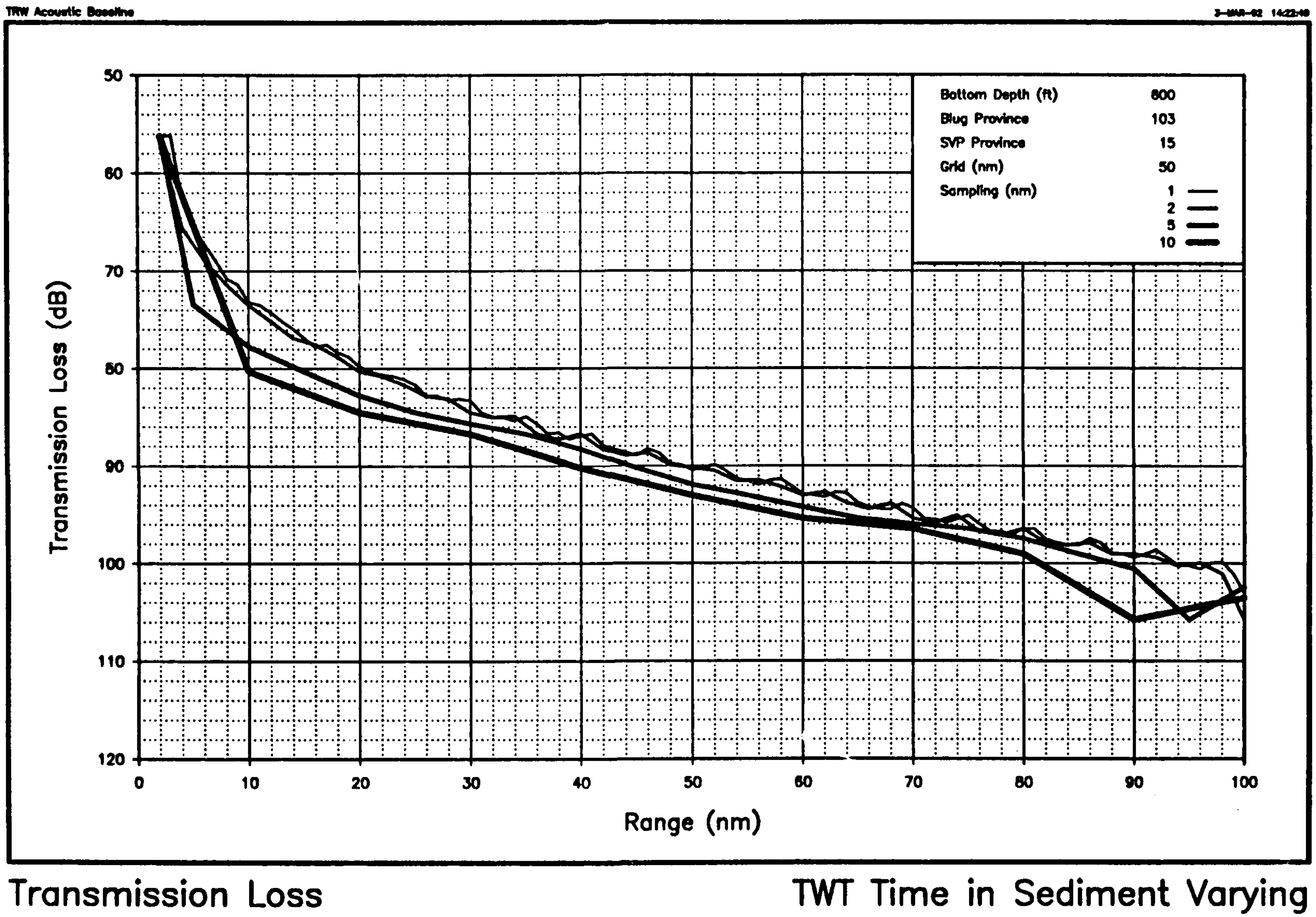


Figure 21. Sediment Thickness Effect, 50 nm Grid, 600 ft Depth

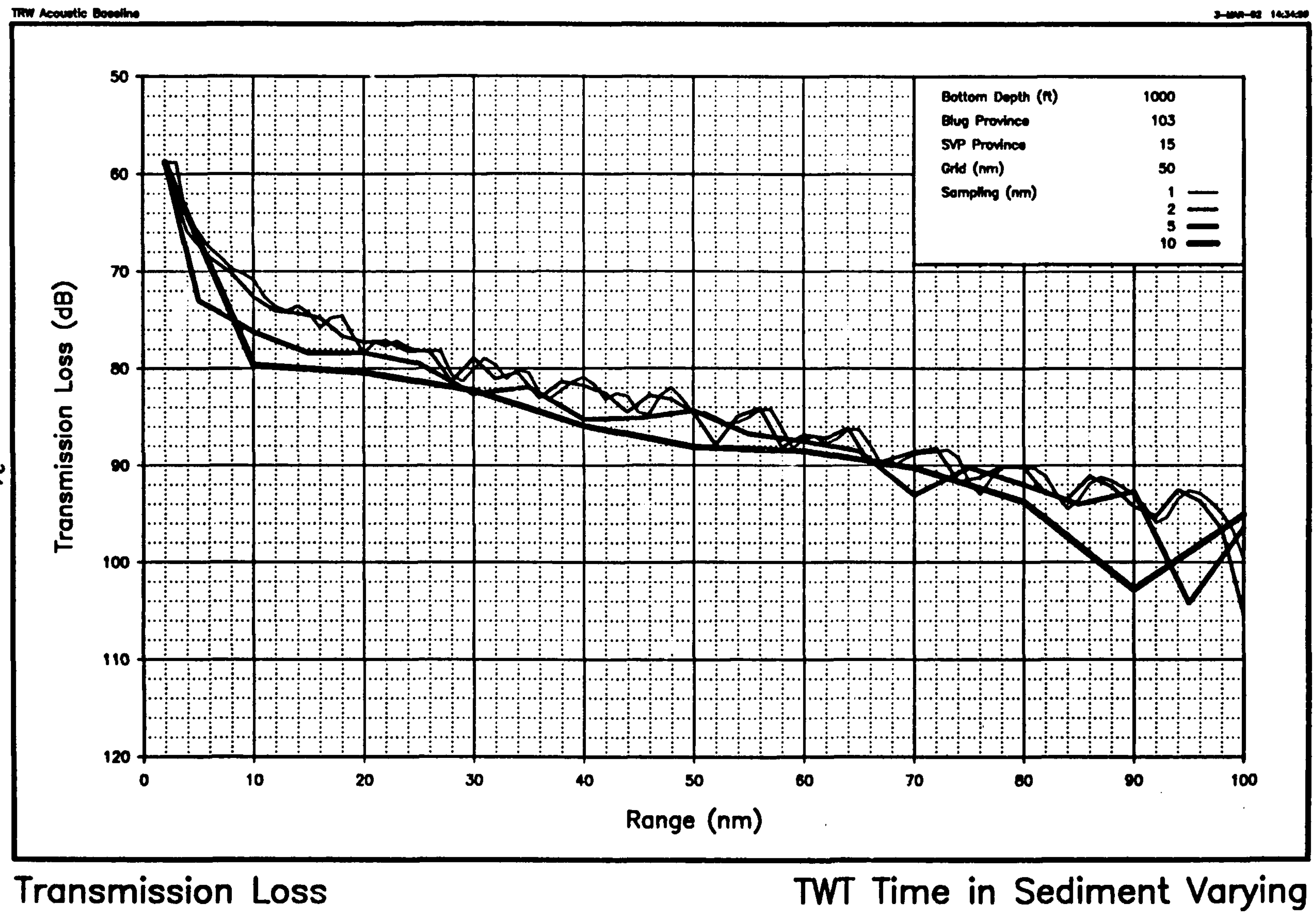


Figure 22. Sediment Thickness Effect, 50 nm Grid 1000 ft Depth

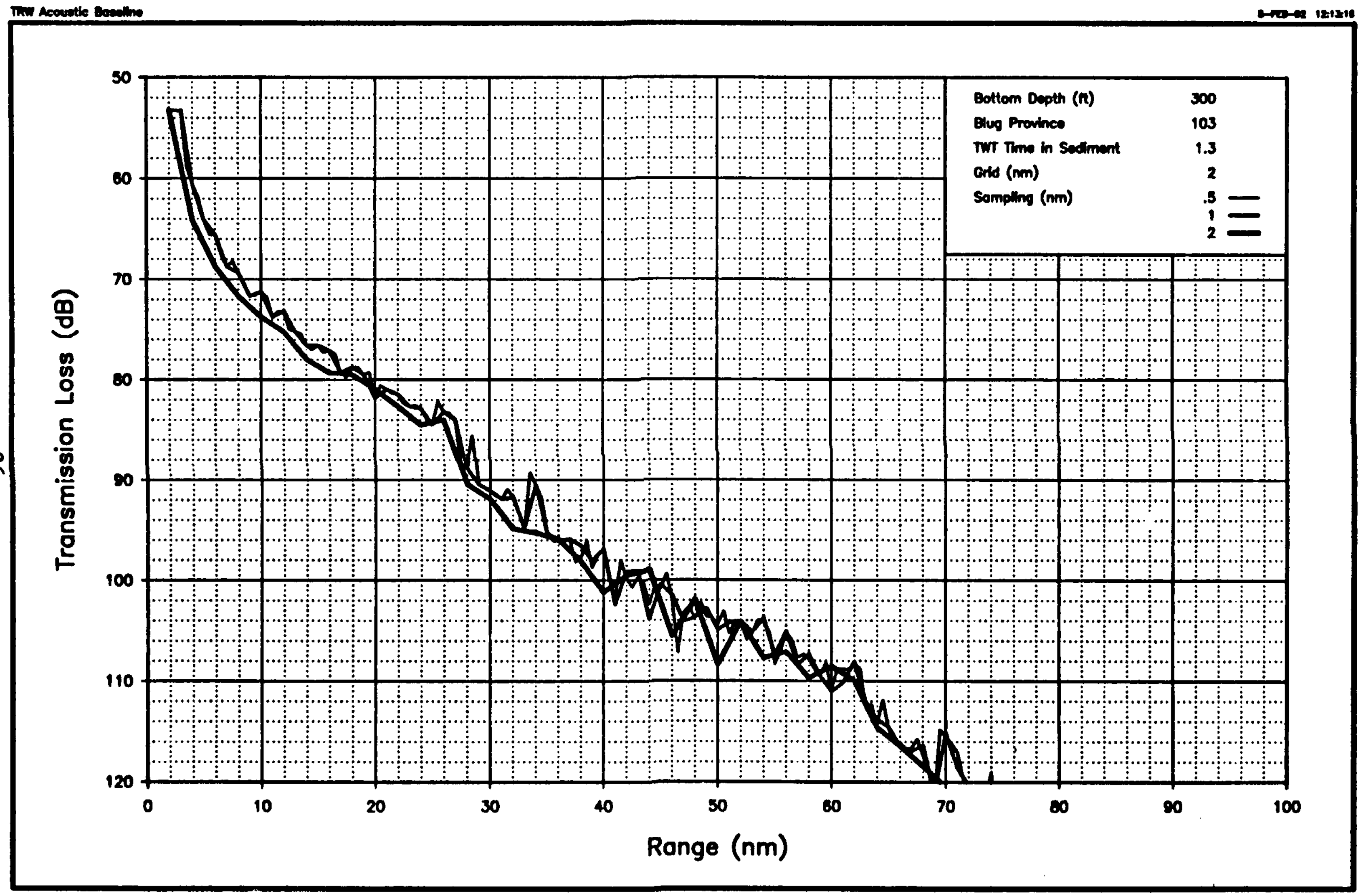
3.1.5 Range-dependent in Sound Velocity Profile

AUAMP calculations, for which BLUG province, sediment thickness, and bottom depth were held constant while the sound velocity profile varied, were performed. Data bases were constructed with various resolution to see the effect of environmental fluctuation rates on the transmission loss coupled with sampling interval changes. AUAMP was run employing different sampling intervals on the various SVP data base grid resolutions for three water depths of 300, 600, and 1000 ft. Table 10 gives the resolution of the artificial data bases constructed for the sound velocity profiles along with the AUAMP sampling intervals used.

Environmental Parameter	Data Base Resolution (Grid) (nm)	AUAMP Sampling interval (nm)
SVP	2	1/2, 1, 2
	5	1/2, 1, 2, 5
	30	1/2, 1, 2, 5, 10

Table 10. Matrix of Sediment Thickness Data Base Resolutions and Sampling Intervals

Figures 23 through 25 show the effects of varying the SVP type on a two nautical mile data base grid for the three bottom depths. Figures 26 through 28 show the effect of varying the SVP on a five nautical mile grid. Figures 29 through 31 show the effect of a 30 nautical mile grid.



Transmission Loss

Figure 23. Sound Velocity Profile Effects, 2 nm Grid, 300 ft Depth

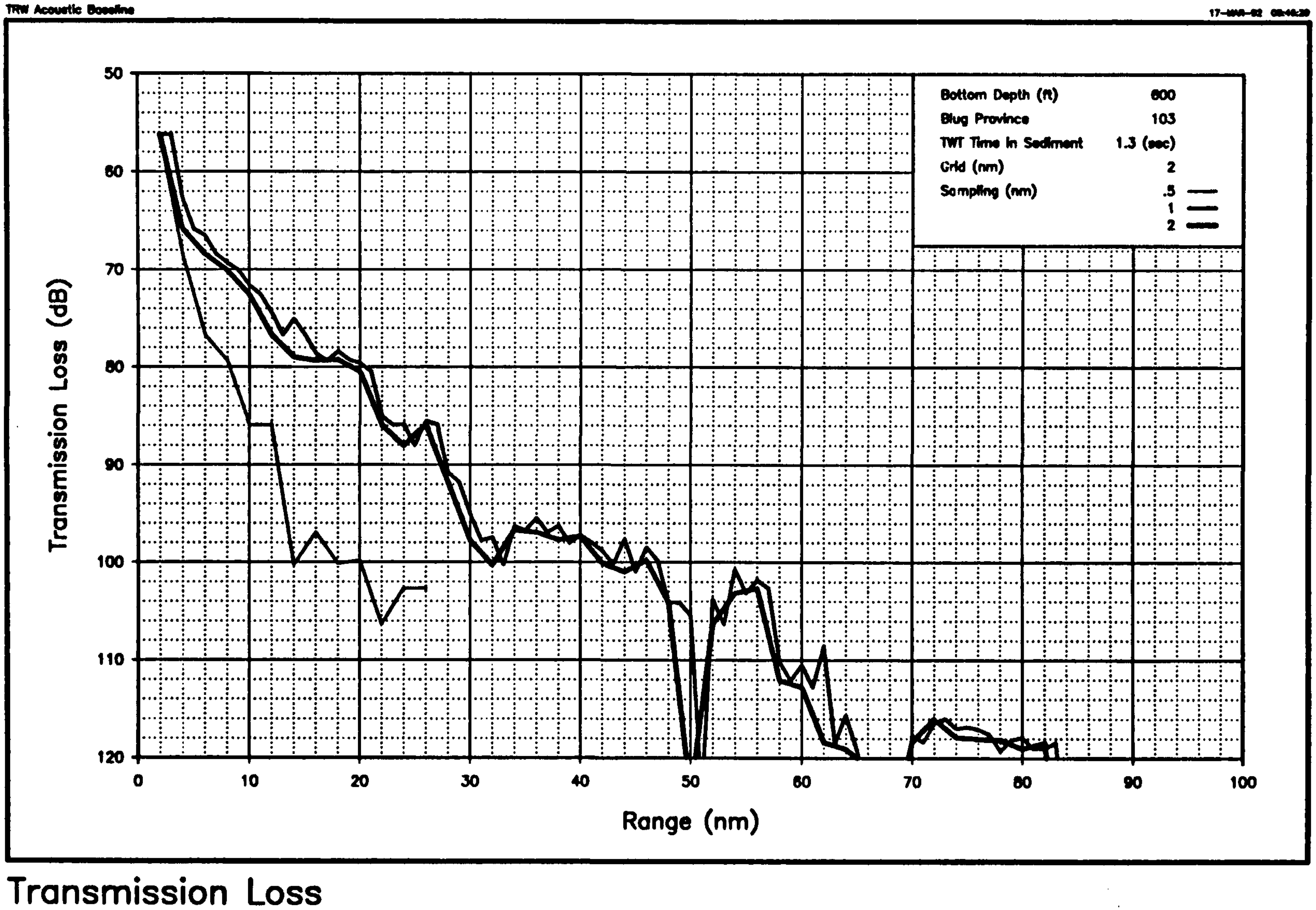
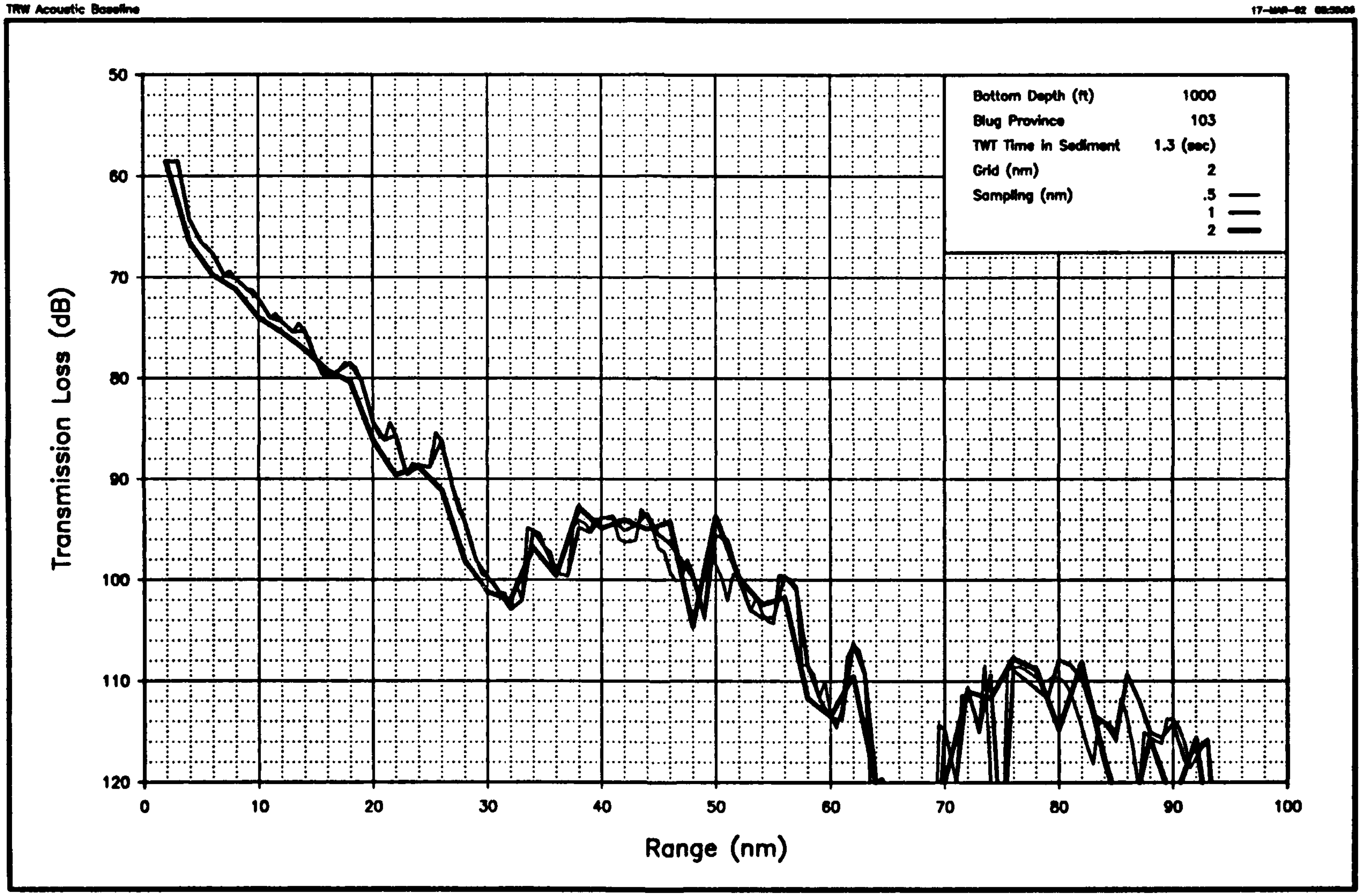
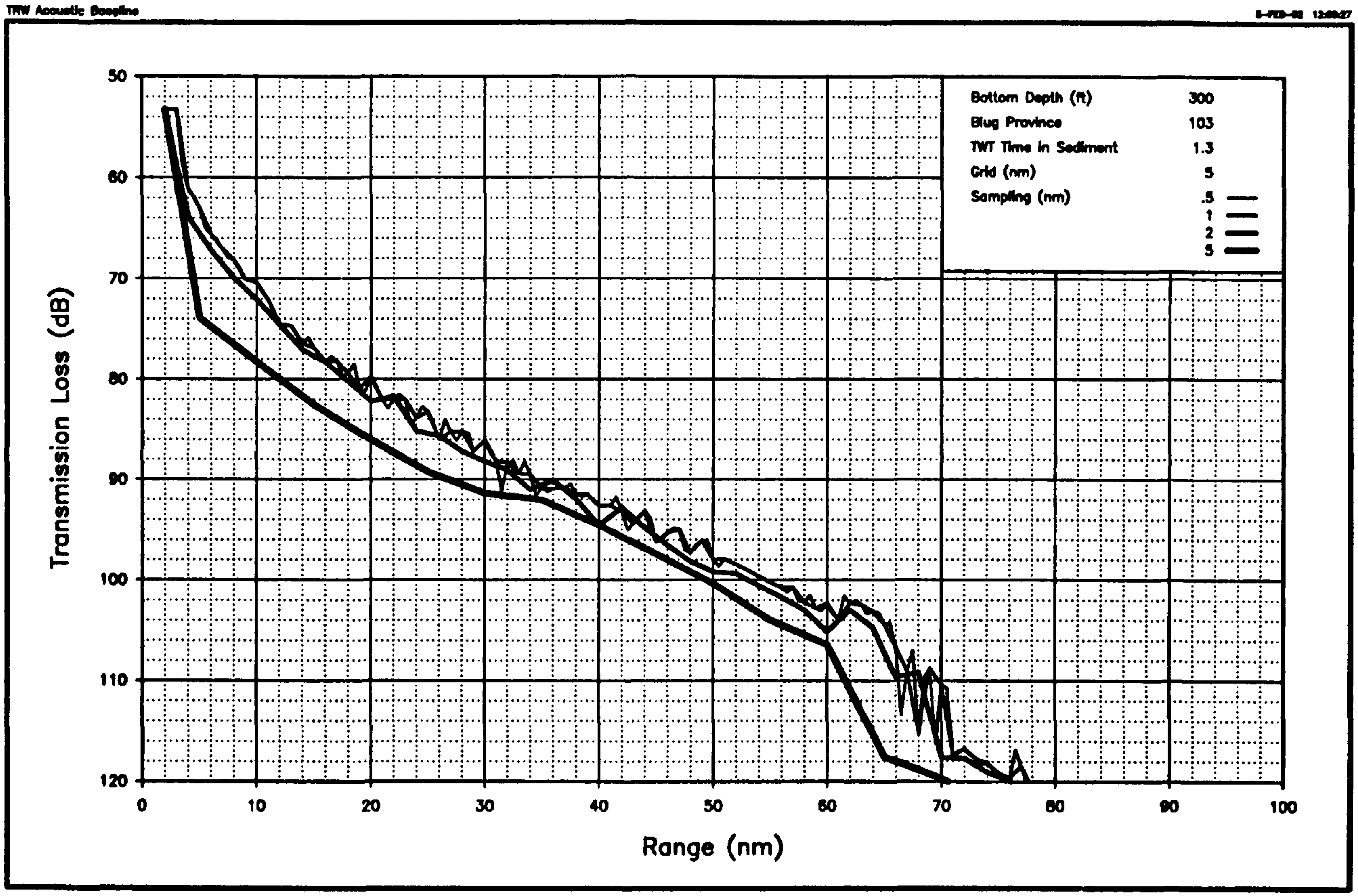


Figure 24. Sound Velocity Profile Effects, 2 nm Grid, 600 ft Depth



Transmission Loss

Figure 25. Sound Velocity Profile Effects, 2 nm Grid, 1000 ft Depth



Transmission Loss

Figure 26. Sound Velocity Profile Effects, 5 nm Grid, 300 ft Depth

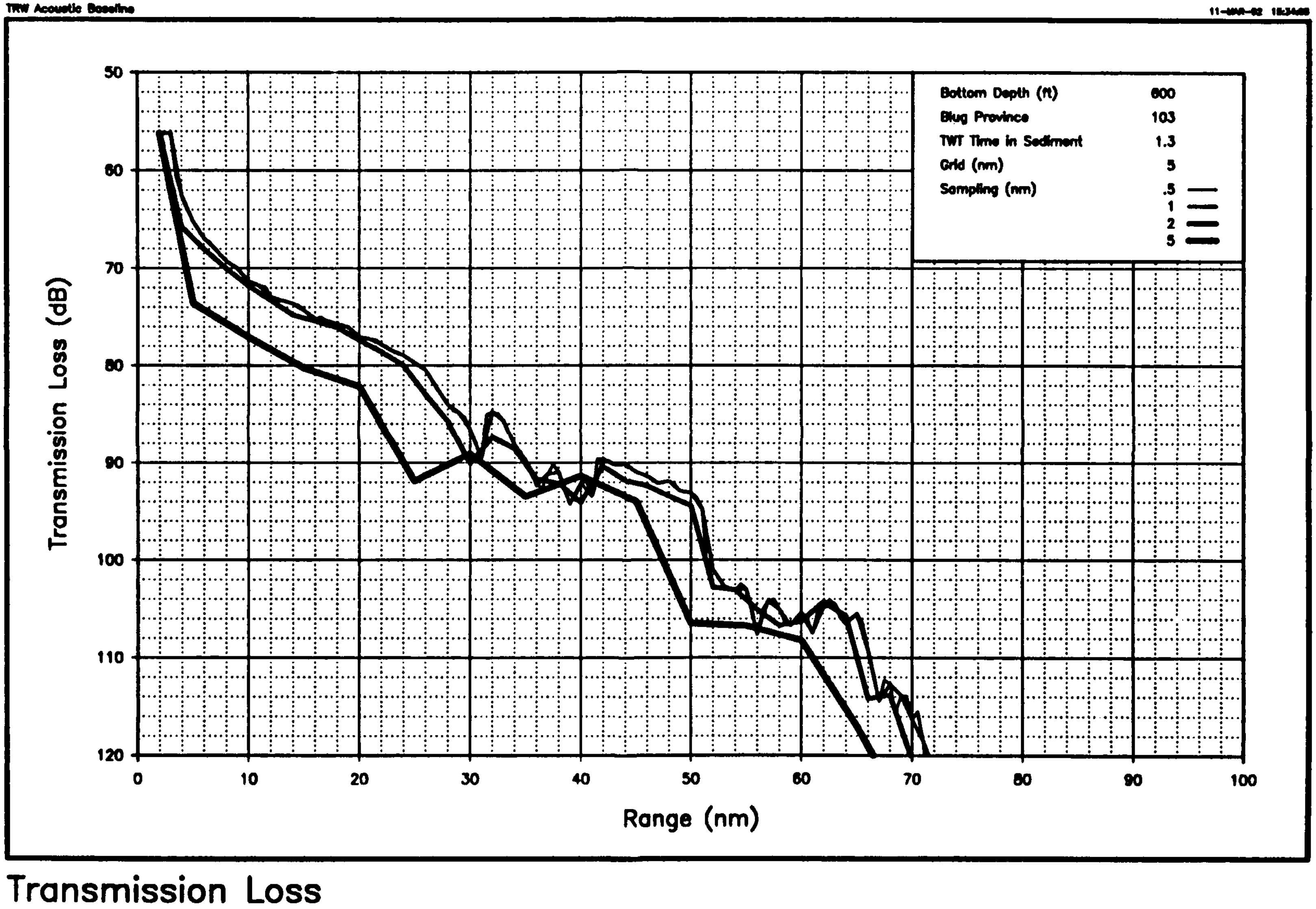
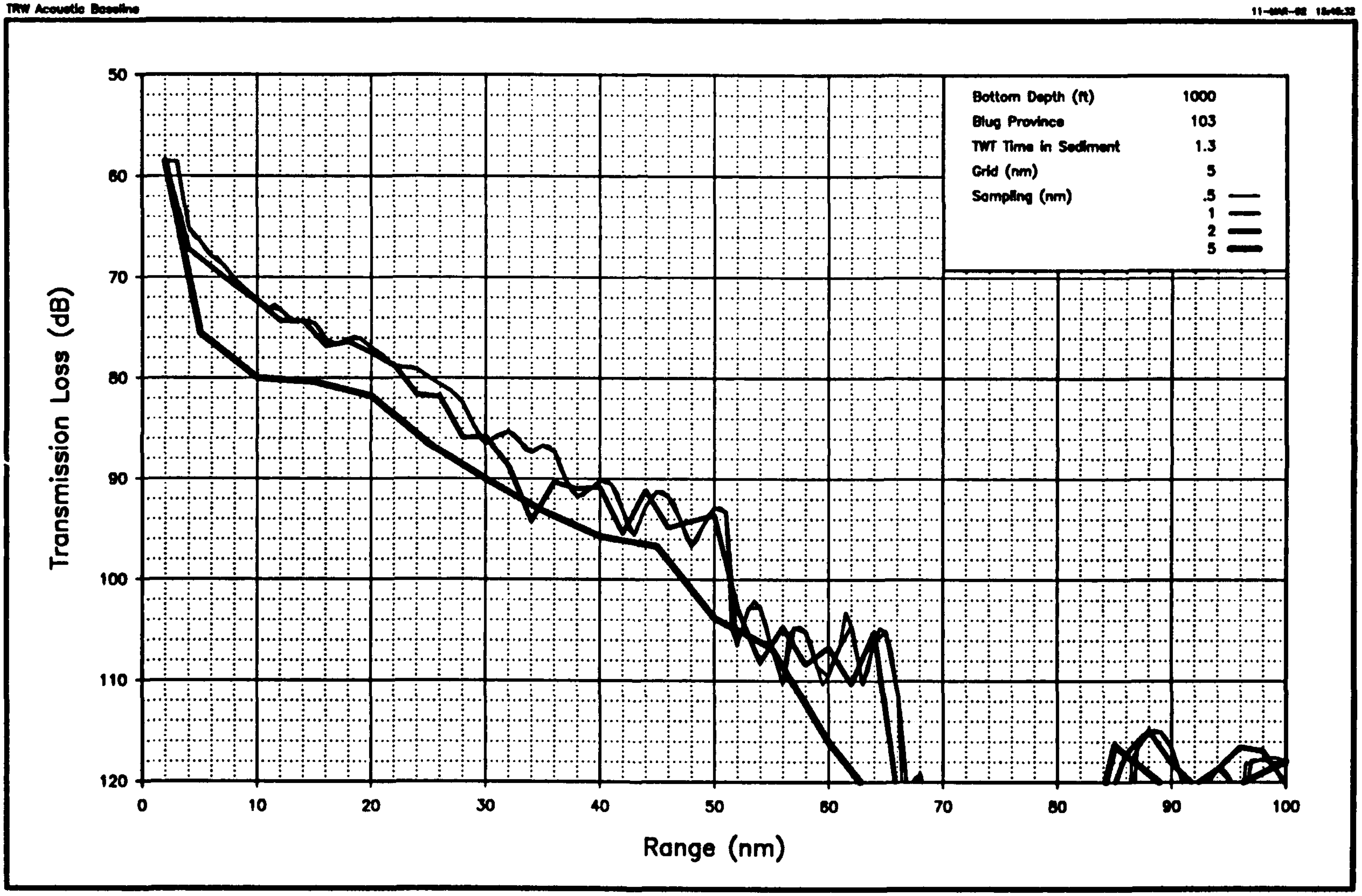
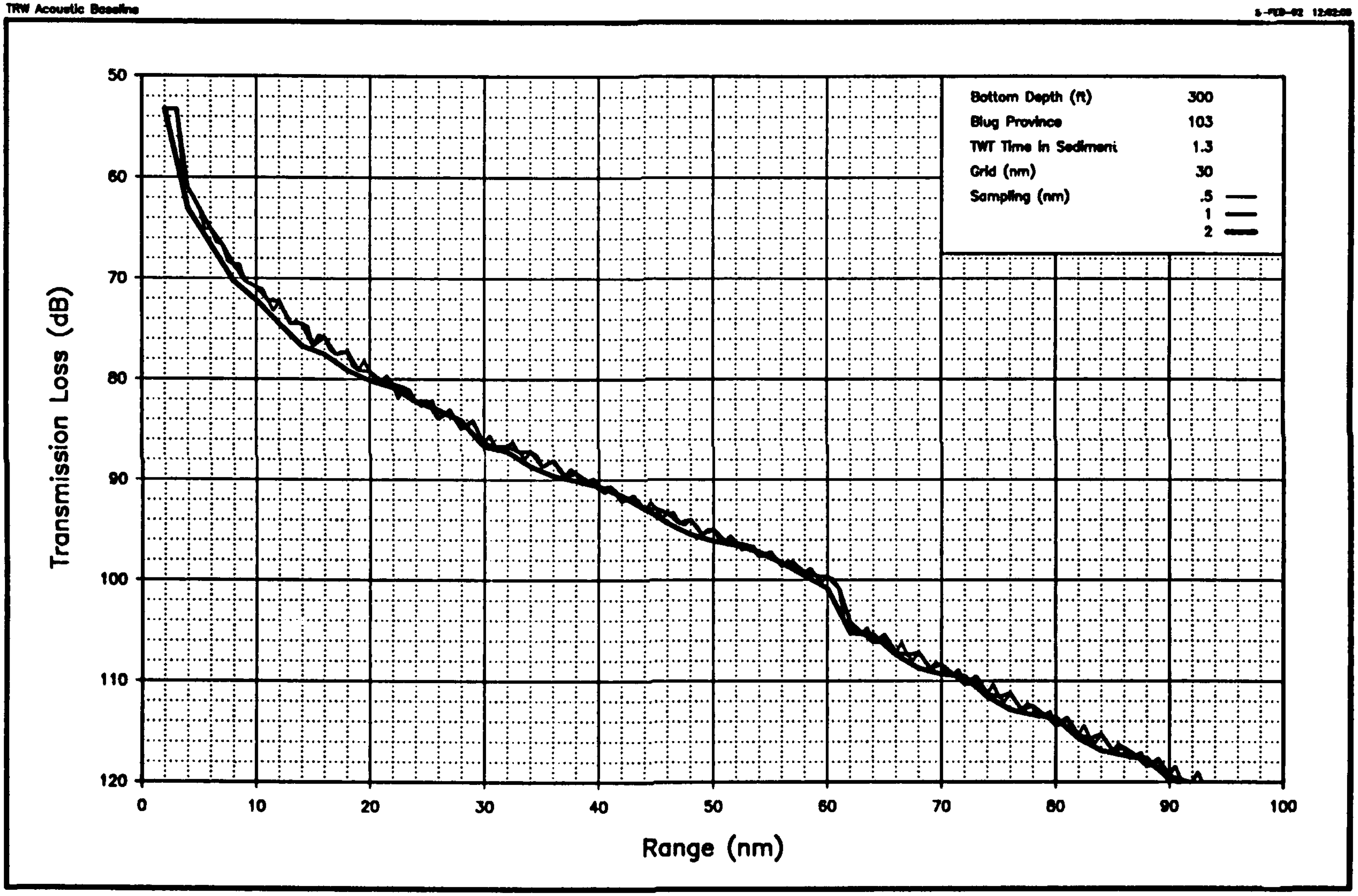


Figure 27. Sound Velocity Profile Effects, 5 nm Grid, 600 ft Depth



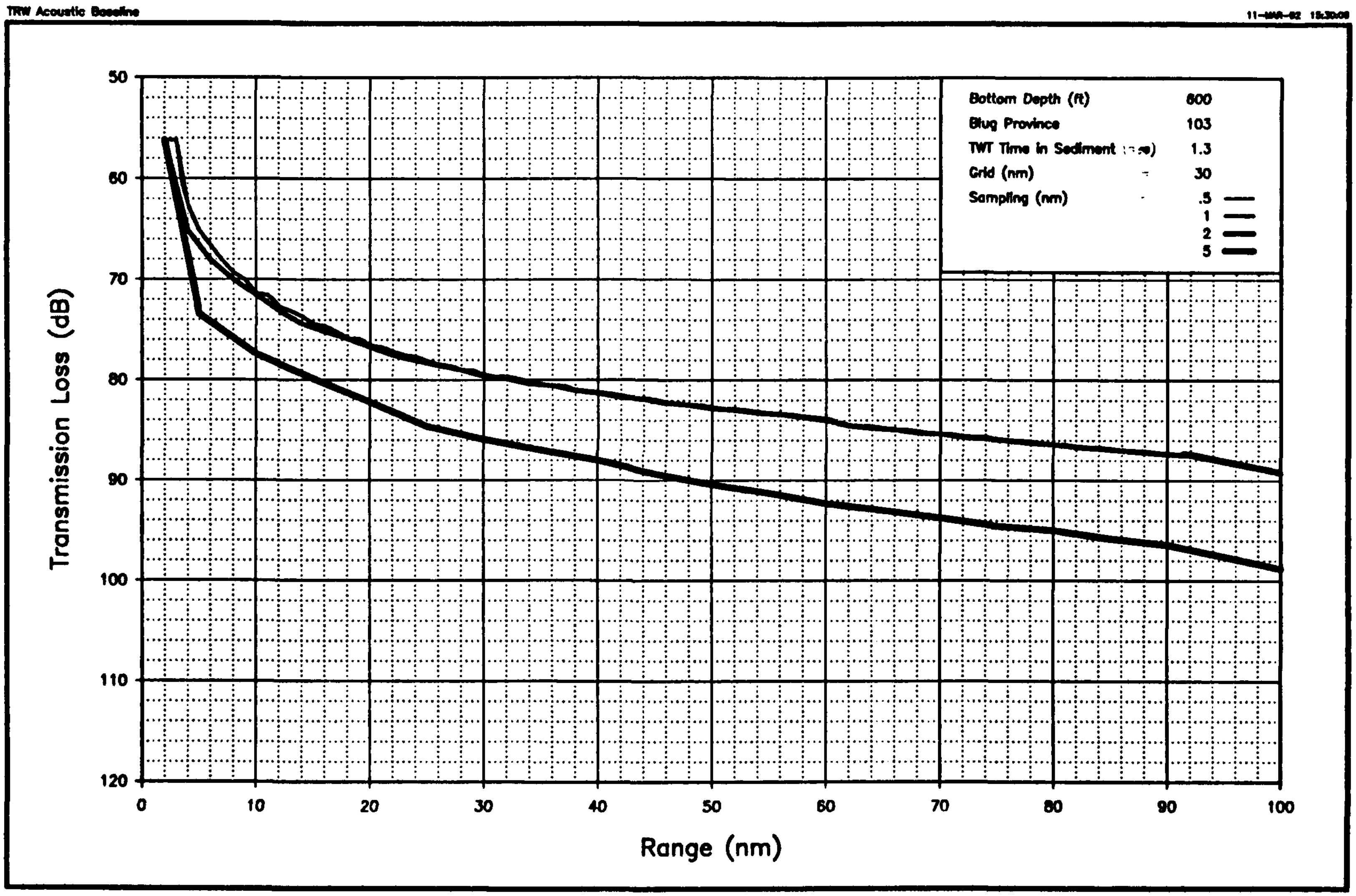
Transmission Loss

Figure 28. Sound Velocity Profile Effects, 5 nm Grid, 1000 ft Depth



Transmission Loss

Figure 29. Sound Velocity Profile Effects, 30 nm Grid, 300 ft Depth



Transmission Loss

Figure 30. Sound Velocity Profile Effects, 30 nm Grid, 600 ft Depth

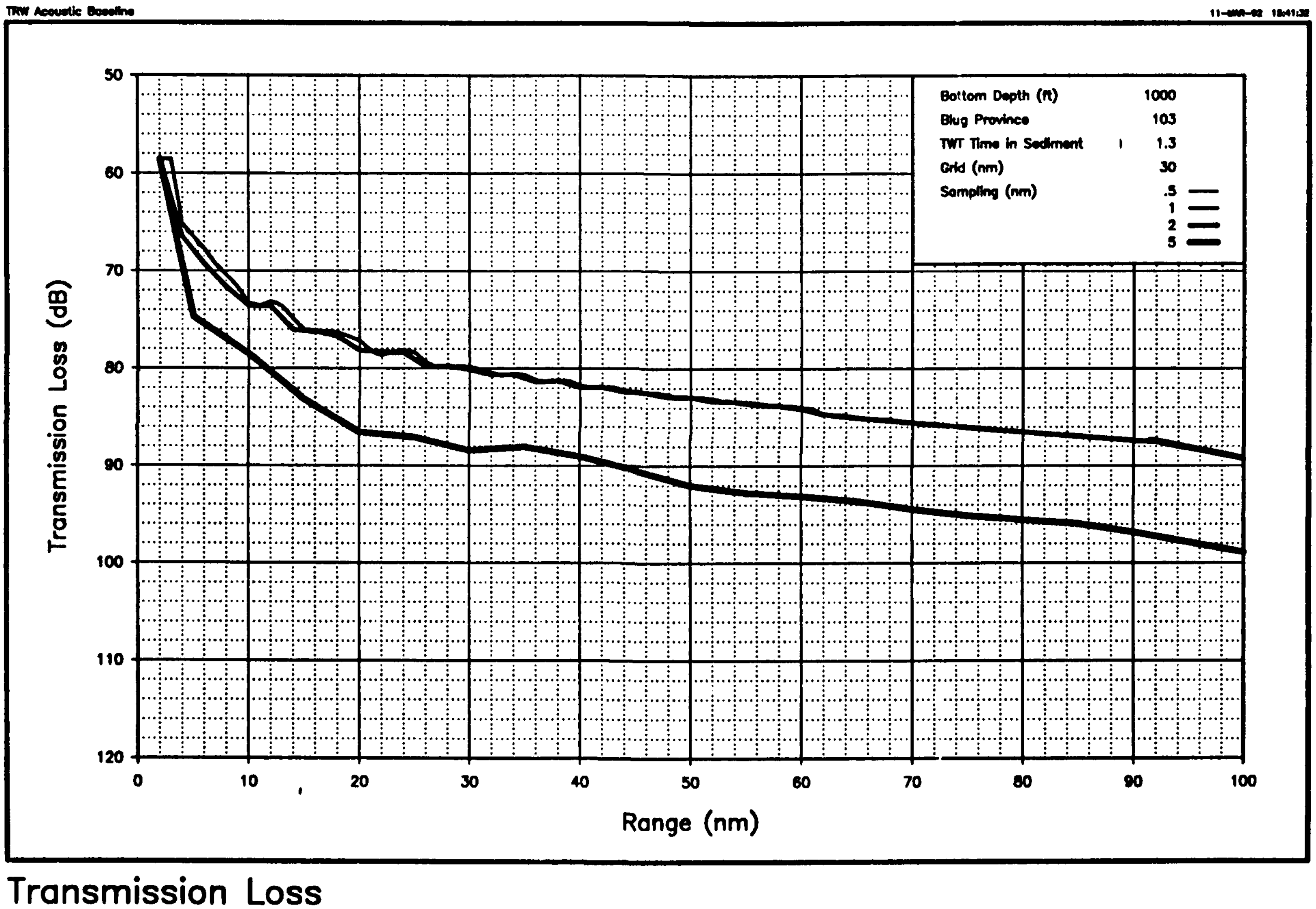


Figure 31. Sound Velocity Profile Effects, 30 nm Grid, 1000 ft Depth

3.1.6 Range-dependent in Bottom Depth

AUAMP TL calculations, for which BLUG province, SVP type, and sediment thickness were held constant while the bottom depth was varied, were performed. Data bases were constructed to see the effect of bottom depth fluctuations at different grid resolutions coupled with various sampling intervals on the transmission loss. The bottom depth data bases were constructed to simulate upslope environments. AUAMP was run employing different sampling intervals on the grid resolutions. Table 11 gives the resolution of the artificial data bases constructed for the bottom depth study along with the AUAMP sampling intervals applied.

Environmental Parameter	Data Base Resolution (Grid) (nm)	AUAMP Sampling interval (nm)
Bottom Depth	1	1/2, 1, 2
	5	1, 2, 5
	50	1, 2, 5, 10

Table 11. Matrix of Bottom Depth Data Base Resolutions and Sampling Intervals

Figure 32 shows the effect of varying the bottom depth on a two nautical mile data base grid. Figure 33 shows the effect of varying the bottom depth on a five nautical mile grid. Figure 34 shows the effect of a ten nautical mile grid.

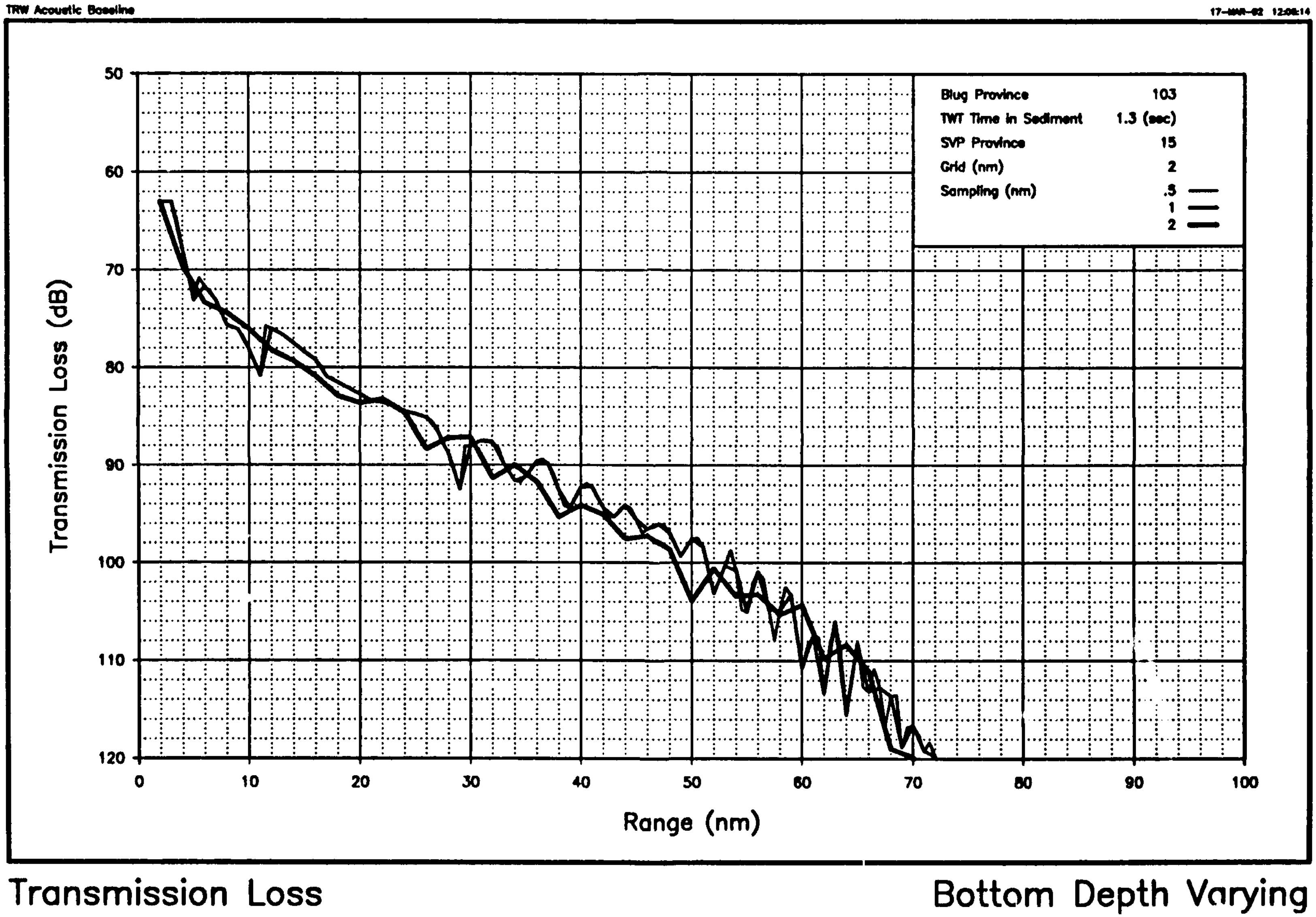


Figure 32. Bottom Depth Effect, 2 nm Grid

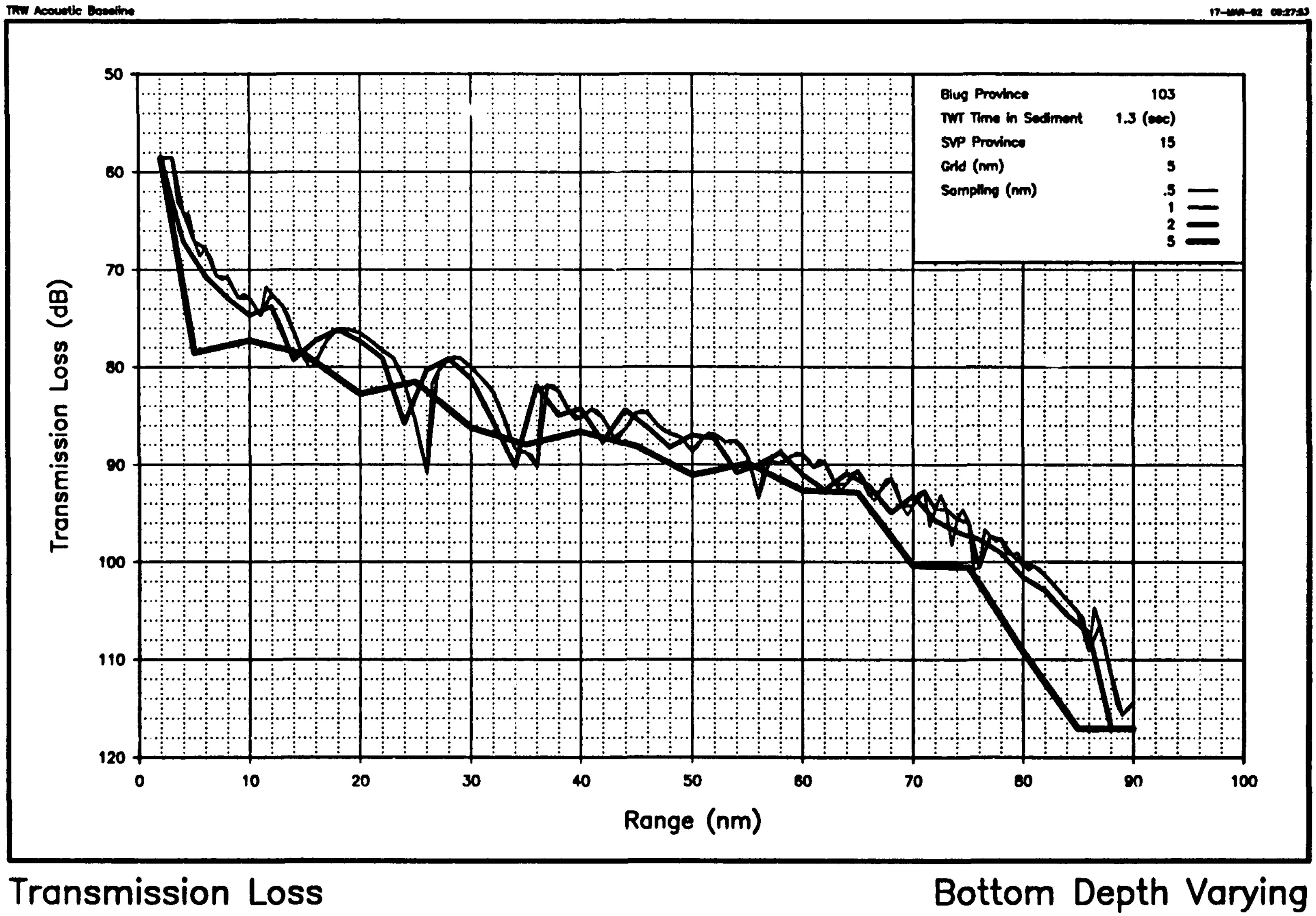


Figure 33. Bottom Depth Effect, 5 nm Grid

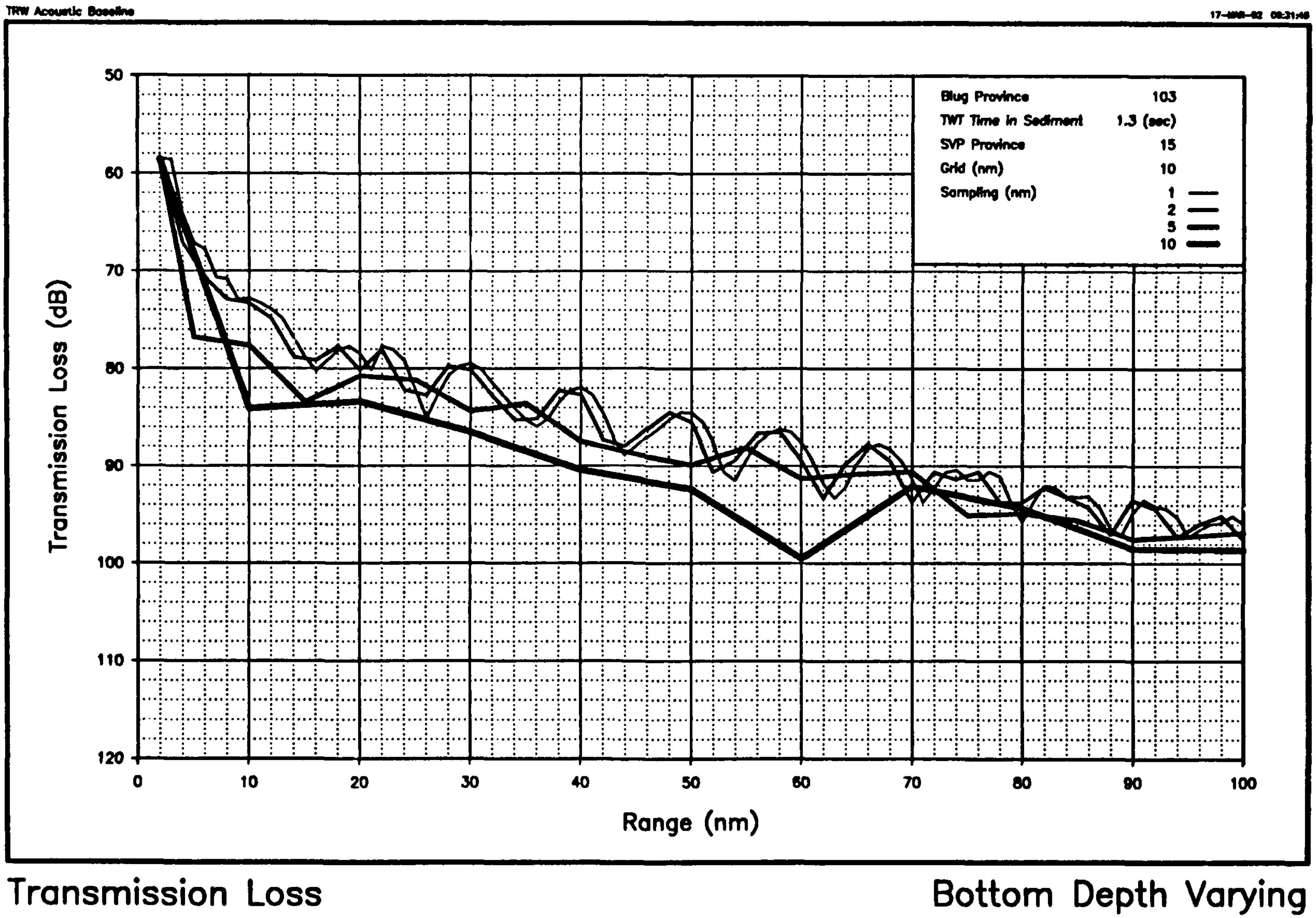


Figure 34. Bottom Depth Effect, 10 nm Grid

3.2 Sensitivity of AUAMP Version 2.6 TL Output to Environmental Parameters

To assist in reviewing the applicability of AUAMP to shallow water predictions, it is helpful to know which environmental parameters have the greatest effect on the transmission loss calculation. AUAMP runs were performed in which three of the four environmental parameters were held constant at the values shown in Figure 6. The fourth environmental parameter was modeled as range dependent on a standard grid resolution with a two nautical mile sampling interval, accessing the data bases described in Appendix A. Table 12 gives the data base grid resolutions used for each of the environmental parameters. Random changes in the environment were used as input to the data bases.

Figure 35 presents four transmission loss curves which reflect the results of the four AUAMP runs in which only one environmental parameter was varied at a time while the other three were held constant. In addition, a range independent curve is plotted to compare with the transmission loss curves generated with fluctuations in each of the environmental parameters. A 300 ft constant bottom depth was used for all the curves in Figure 35 with the exception of the bottom depth varying transmission loss curve. Figure 36 presents the effect of fluctuations in individual environmental parameters on the transmission loss calculation for a bottom depth of 600 ft. Figure 37 presents the effect of fluctuations in individual environmental parameters on the transmission loss calculation at a bottom depth of 1000 ft.

Parameter	Grid Resolution (nm)
BLUG Province	5
SVP Type	30
Sediment Thickness	5
Bottom Depth	5

Table 12. Grid Resolutions used at Constant Sampling Rate

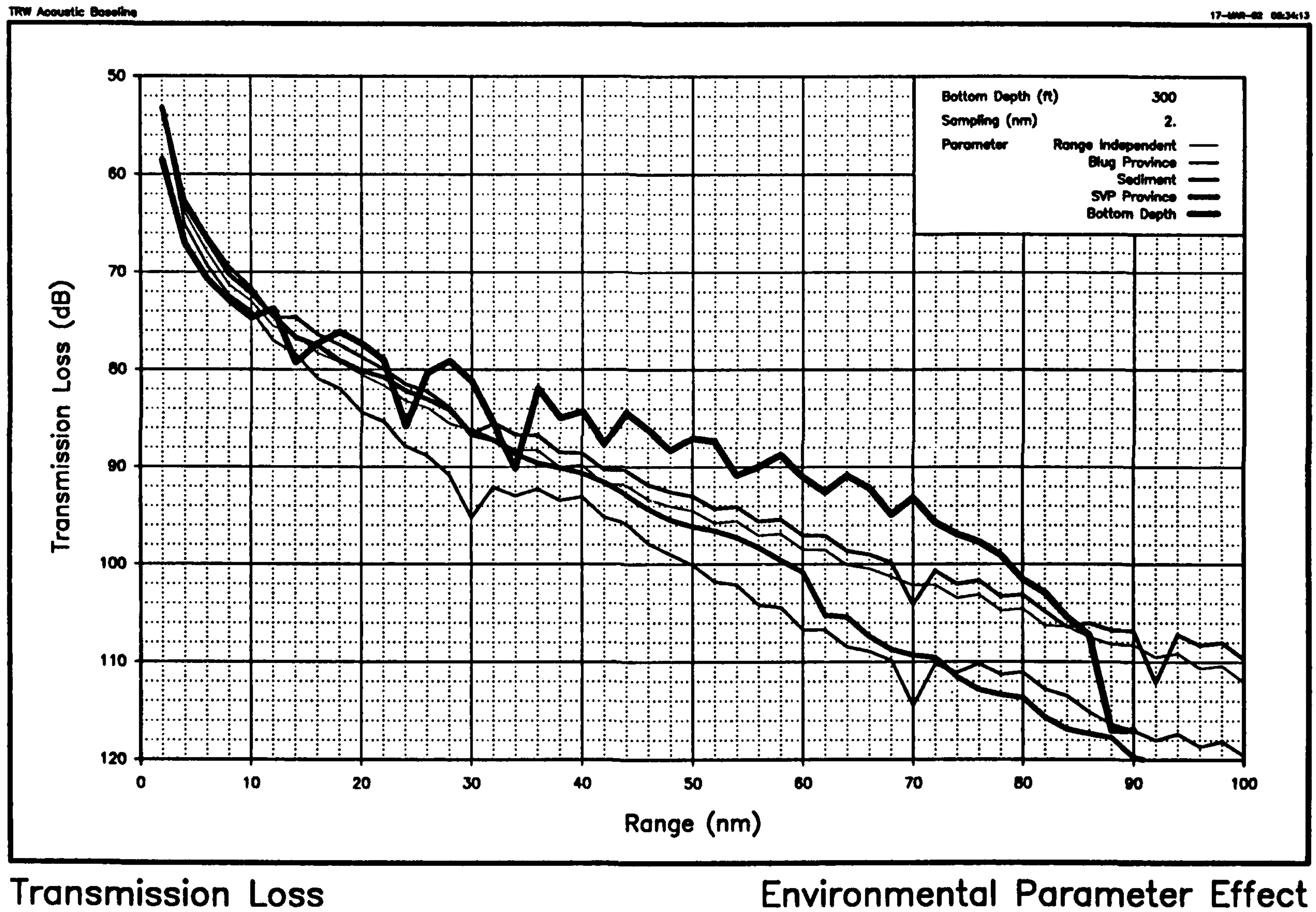


Figure 35. Effects of Environmental Parameter Changes on TL Calculation, 300 ft

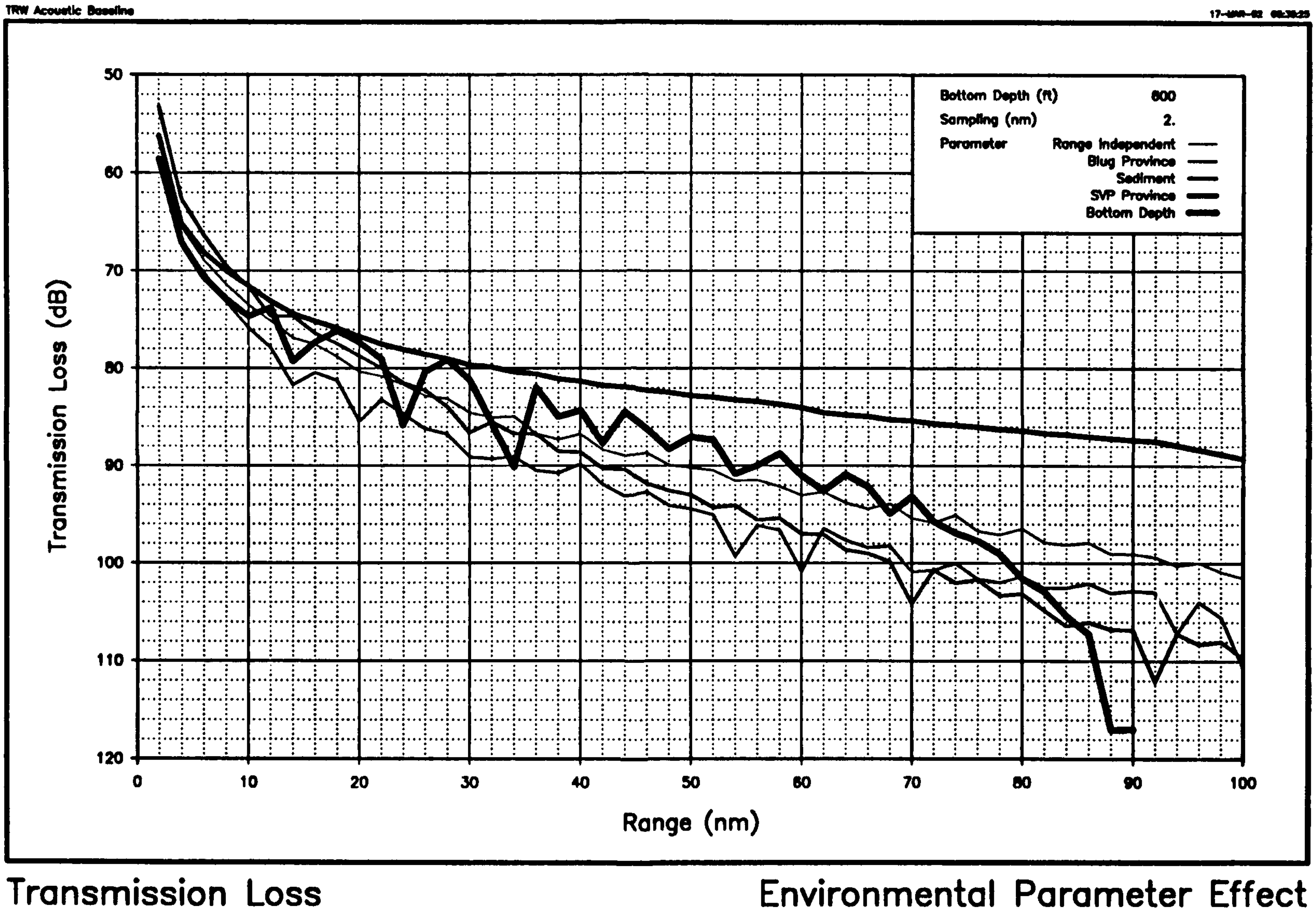
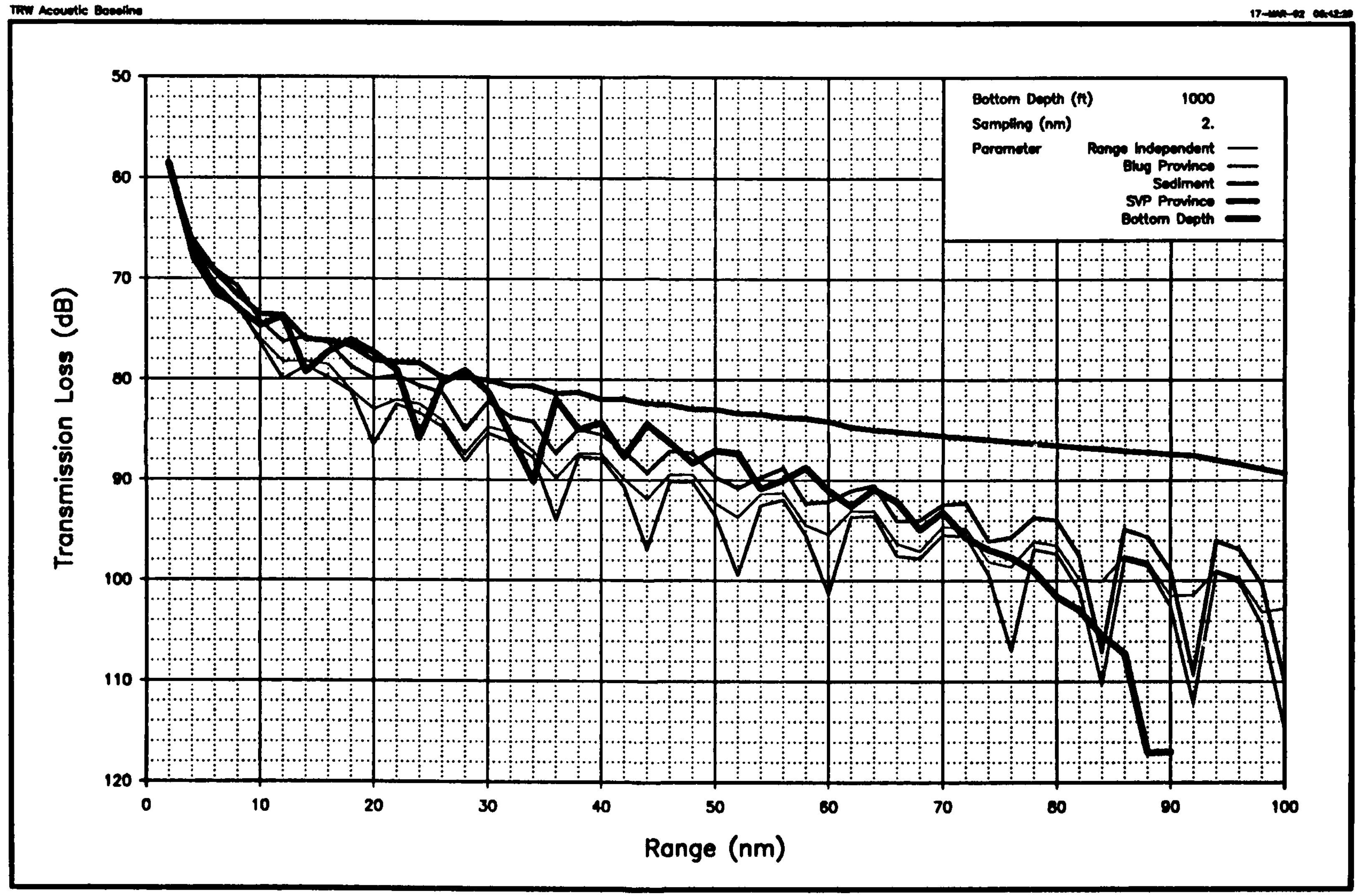


Figure 36. Effects of Environmental Parameter Changes on TL Calculation, 600 ft



Transmission Loss Environmental Parameter Effect

Figure 37. Effects of Environmental Parameter Changes on TL Calculation, 1000 ft

4.0 PRELIMINARY OBSERVATIONS

Observations from the analysis outlined in this paper are described below in Section 4.1. Section 4.2 presents preliminary conclusions. The observations and preliminary results reported in this section will be further investigated with analysis into the physics and implementation of the model as well as comparisons with real data.

4.1 General Observations

Each general observation is discussed below with reference to the appropriate AUAMP TL run(s) used to support the observation.

- **The two nautical mile AUAMP sampling interval does not appear sufficient to predict the TL structure in all shallow water environments.**

This is demonstrated with Figure 8 which reflects the transmission loss in an environment that is only varying in BLUG province every five nautical miles, at a constant bottom depth of 300 ft. There is a significant fine structure difference between the two nautical mile sampling interval and the one nautical mile sampling interval curves. Even more noticeable is the offset in range and level of the transmission loss between the two nautical mile and one nautical mile sampling interval curves. The coarser sampling interval (two nm) lowers the entire TL curve and offsets it in range. This is especially noticeable of ranges greater than 50 nautical miles. The offset is increased by moving to yet a coarser sampling interval as shown with the five nautical mile sampling interval curve.

The inadequacy of the 2 nm sampling rate to predict the TL structure is shown in Figures 32 through 34, which reflect the transmission loss in an environment that is only varying in bottom depth every five nautical miles. There is a fine structure difference and curve offset between the one and two nautical mile sampling intervals.

It is interesting to note that there is not a significant difference between the 1/2 and

one nautical mile sampling interval curves either in fine structure or offset as between the two and one nautical mile sampling interval curves. This implies that the one nautical miles sampling interval will be sufficient in environments where the two nautical mile sampling interval is not.

It appears that the inadequacy of the two nautical mile sampling rate is dependent on the environment. When the BLUG province or bottom depth is varying, the difference between the two and one nautical mile sampling rates are significant. In environments in which only the sediment thickness is varying, as shown in Figure 17 on a five nautical mile grid, there is not an appreciable difference between the one and two nautical mile sampling intervals. In environments in which only the sound velocity profile is varying, the difference between the one and two nautical mile sampling interval is not significant either.

- **When coarse grids are employed, a two nautical mile or one nautical mile sampling interval is still required.**

This is demonstrated in Figure 11 in which the transmission loss as a result of the BLUG province varying every 50 miles is plotted. There is a considerable offset (4 dB in level) between the five and two nautical mile sampling interval curve. The two nautical mile sampling interval curve does not appear to pick up the entire TL structure. This is an interesting effect as it shows the independence of the AUAMP sampling interval to environmental changes since in this example the BLUG province is changing only every 50 miles.

It is useful at this point to refer back to Figure 2, the range-independent transmission loss curve at a bottom depth of 300 ft. Figure 2 does not show the significant offset that Figure 11 shows between the various sampling interval curves. This is an interesting result. The BLUG type used to generate the range-independent curve is 14 as shown in Table 6. The BLUG type used to generate the curve shown in Figure 11 started with BLUG type 1 as presented in Appendix A. Comparing Figure 11 and Figure 2, it appears that depending on the actual value of the data entered, the AUAMP sampling interval has different effects.

The effect of specific data having an impact on the sampling interval effect is further demonstrated in the comparison of Figures 2 and 20. Figure 20 presents a transmission loss curve in which only sediment thickness is varying every 50 nautical miles. Figure 2 is the range independent transmission loss curve.

- **As the water depth decreases, the need for a finer sampling interval is increased.**

This effect can be seen by comparing Figures 8 and 9, which presents transmission loss curves over two bottom depths of 300 and 600 ft in which only the BLUG province was varying with range. Looking at the one and two nautical mile sampling interval curves, the difference between the sampling interval effects on the transmission loss decreases as the depth increases to 300 ft from 600 ft. In addition, there is not as fine a structure at the 600 ft depth (Figure 9) relative to the 300 ft depth (Figure 8).

This can also be seen in environments in which only the sediment thickness varies. Figures 14 and 15 present transmission loss in which sediment thickness is varying every one nautical mile for a 300 and 600 ft bottom depth. The 1/2, one and two nautical mile sampling interval curves converge upon going from the 300 ft depth (Figure 14) to the 600 ft depth (Figure 15). Thus, it appears that in shallow water (300, 600 ft) finer sampling intervals better predict the fine structure of the TL.

- **In environments in which the bottom depth is changing often, the effect of the sampling interval on the transmission loss is significant relative to sampling interval effects on the three other environmental parameters.**

This is demonstrated in Figures 32 through 35 which present transmission loss given upslope changes in bottom depth. For a five nautical mile grid (Figure 33) there is a significant change between the two nautical mile sampling interval and the one nautical mile sampling interval curves. There is even an appreciable variance of about three dB between the 1/2 and one nautical mile sampling interval curves at ranges greater than 73 nm. This indicates the transmission loss function is very sensitive to the bottom depth relative to the

three other environmental parameters at a two nautical mile sampling interval. None of the other environmental parameters dictated the use of a 1/2 nautical mile sampling rate.

The two nautical mile sampling interval does not appear to be predicting the entire transmission loss structure in upslope environments. This is a significant effect as AUAMP comparisons (using a two nautical mile sampling interval) with real data have been known to decay in slope environments.

- **The general sensitivity of AUAMP to various input range-dependent parameters is very dependent on the data input to AUAMP.**

For the random type variances used in this report, it appears that bottom depth has the greatest effect on transmission loss as seen in Figure 35. The SVP affects the transmission loss significantly more than the BLUG province at bottom depths of 600 and 1000 ft (Figure 36 and 37). In shallower environments, the BLUG province tends to have an increased effect on the transmission loss calculation due to the increased bottom interaction. The sediment thickness appears to have the least relative effect on the transmission loss at any depth.

4.2 Preliminary Conclusions of Work-to-Date

Analysis to date provides the following conclusions:

- It appears the sampling interval has a greater effect on the transmission loss in environments in which the bottom depth is changing relative to changes in other environmental parameters;

- The two nautical mile sampling interval presently employed by AUAMP does not appear sufficient all the time. In particular, very shallow water environments (300 ft) and upslope type environments require a finer sampling interval (one

nautical mile);

- A coarse sampling interval tends to neglect the fine structure of the transmission loss and may lower the entire curve a specific dB amount and translate it in range;

- Coarser data grids than the data base grids currently employed by AUAMP, for all environmental parameters, still dictate the use of a two nautical mile or finer sampling interval;

- In a very shallow water environments (300 ft) the BLUG province and SVP profile have a greater effect on the transmission loss than they do in deeper water.

REFERENCES

1. "AUAMP Baseline 2.1 User's Guide," Science Applications International Corporation, McLean, VA, 1 September 1991.

2. "AUAMP Baseline 21. Description of Physics," Science Applications International Corporation, McLean, VA, 19 September 1987.

3. "Development of the Geo-Acoustic Areas For the Bottom-Loss Upgrade," Science Applications International Corporation, McLean, VA, March 1983.

4. "Data Base Description For Low-Frequency Bottom Loss (LFBL)," Naval Oceanographic Office, Stennis Space Center, Mississippi, June 1990.

5. "The ASTRAL Model, Technical Description," Science Applications Inc., McLean, VA, January 1979.

Appendix A
Artificial Data Base Values

A.1 OVERVIEW

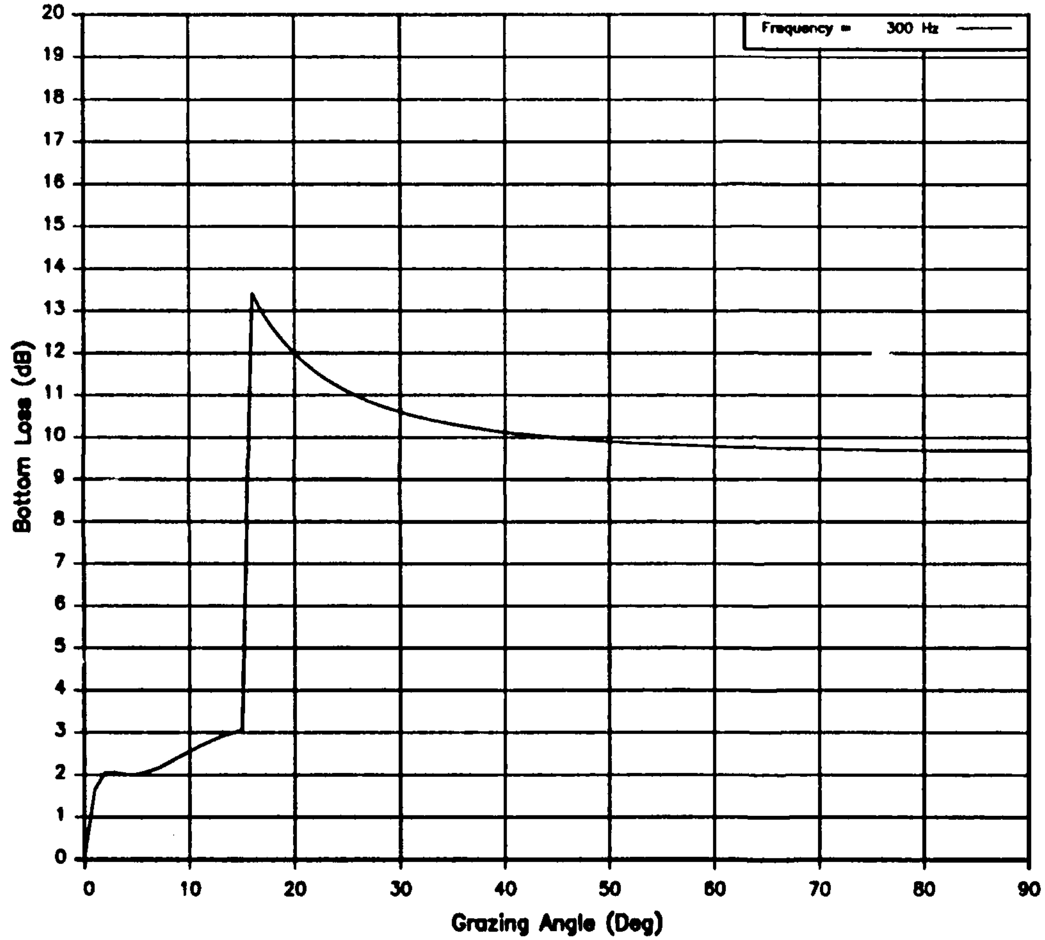
This appendix presents the data used in the artificial data bases that were accessed by AUAMP to generate the results presented in this paper. Four major categories of data bases were constructed: BLUG province; SVP province, sediment thickness, and bottom depth. Each category will be discussed separately and the technique to build the artificial data bases will be presented along with the data bases in tabular form.

A.2 BLUG PROVINCE

The BLUG geoacoustic parameters are accessed through province numbers in the LFBL data base. The BLUG province artificial data base consists of a matrix of BLUG province values. The LFBL data base was accessed to obtain the geoacoustic parameters associated with the province numbers in the artificial data base. Province values that were considered reasonable and to represent possible changes that could occur were chosen. Reference 3 provided a source to identify reasonable changes in the ocean.

The artificial BLUG data base is comprised of 19 BLUG province values. AUAMP accessed this artificial data base at varying frequencies. The frequency of access was dictated by the unique grid resolution for a specific run. For example, if the grid resolution was five nautical miles AUAMP would get a new BLUG province number from the data base every five nautical miles. If the artificial data base grid was fine enough that it went through nineteen values and still needed more to finish the calculation, the data base would stick the first province value into the 20th grid point and cycle through the 19 province values again. For example, if the grid was two nautical miles, to extend out 100 miles in range (which was the chosen range to calculate TL), the 19 BLUG province number would be used over five times. Similarly, if the grid was 50 miles only the first two BLUG provinces of the nineteen would be used.

The bottom loss versus grazing angle curves generated from each of the 19 BLUG provinces' geoacoustic parameters are shown in Figures A1 through A19. A bottom depth of 1000 ft was assumed with the sound velocity at that depth to correspond to the sound velocity type 7 profile value for the generation of the curves.



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.66
2.0	2.06
3.0	2.05
4.0	2.01
5.0	2.01
6.0	2.08
7.0	2.16
8.0	2.29
9.0	2.43
10.0	2.56
12.0	2.80
14.0	2.99
16.0	13.41
18.0	12.58
20.0	11.99
22.0	11.56
24.0	11.23
26.0	10.97
28.0	10.77
30.0	10.61
32.0	10.47
34.0	10.36
36.0	10.27
38.0	10.19
40.0	10.12
42.0	10.07
44.0	10.02
46.0	9.97
48.0	9.94
50.0	9.90
52.0	9.87
54.0	9.85
56.0	9.83
58.0	9.81
60.0	9.79
65.0	9.75
70.0	9.73
75.0	9.71
80.0	9.70
85.0	9.69
90.0	9.69

BLUG—Derived Bottom Loss

Type 1

Figure A1. BLUG Province Type 1, Bottom Loss versus Grazing Angle

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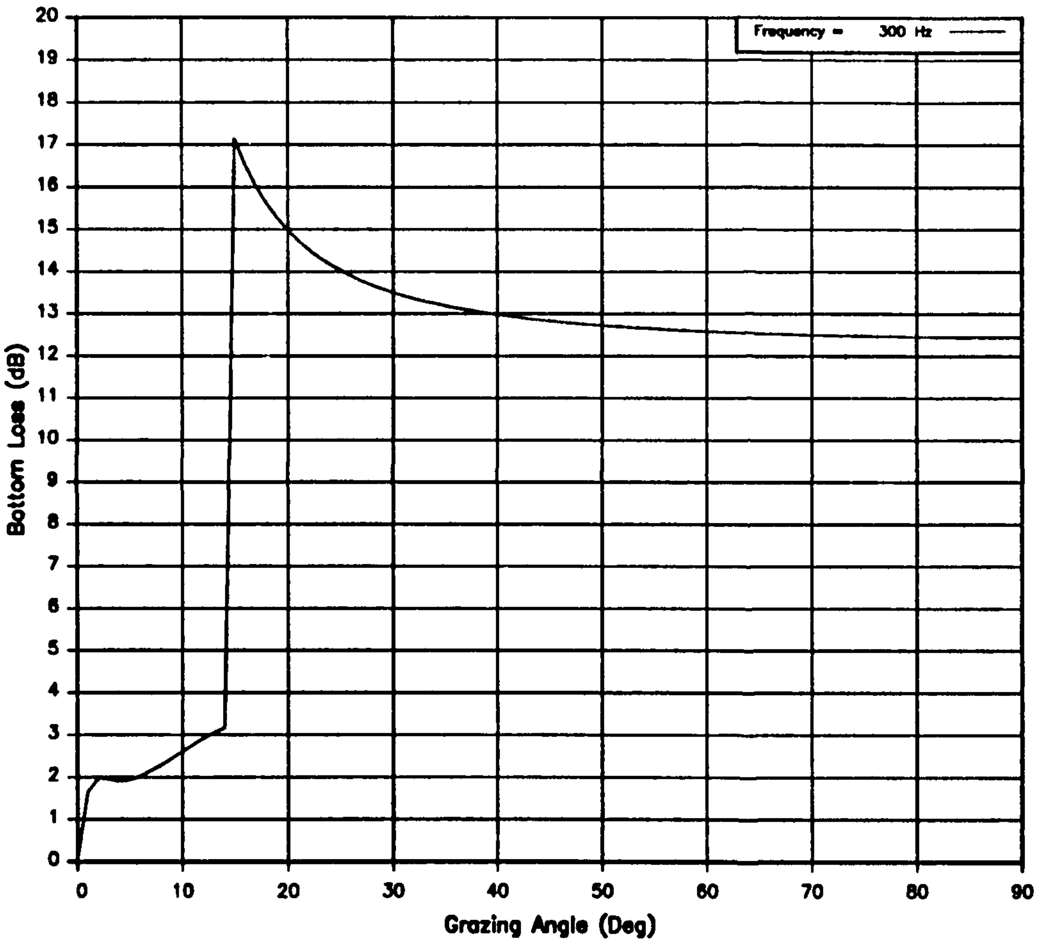


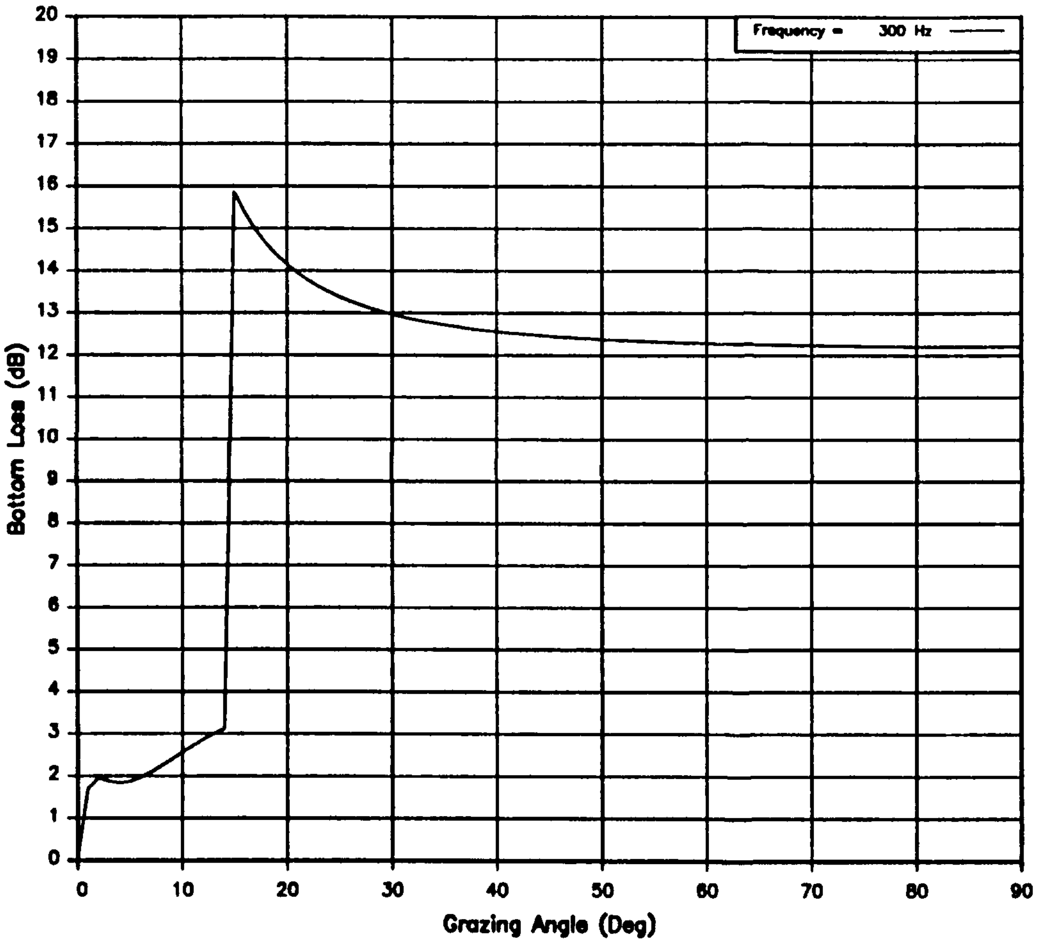
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.65
2.0	1.98
3.0	1.95
4.0	1.91
5.0	1.94
6.0	2.02
7.0	2.16
8.0	2.29
9.0	2.45
10.0	2.61
12.0	2.92
14.0	3.17
16.0	16.52
18.0	15.62
20.0	14.98
22.0	14.52
24.0	14.17
26.0	13.90
28.0	13.68
30.0	13.51
32.0	13.36
34.0	13.25
36.0	13.14
38.0	13.06
40.0	12.98
42.0	12.92
44.0	12.86
46.0	12.81
48.0	12.77
50.0	12.73
52.0	12.70
54.0	12.67
56.0	12.64
58.0	12.61
60.0	12.59
65.0	12.54
70.0	12.50
75.0	12.48
80.0	12.46
85.0	12.45
90.0	12.45

BLUG–Derived Bottom Loss

Type 2

Figure A2. BLUG Province Type 2, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.70
2.0	1.95
3.0	1.88
4.0	1.84
5.0	1.87
6.0	1.97
7.0	2.09
8.0	2.24
9.0	2.40
10.0	2.57
12.0	2.87
14.0	3.12
16.0	15.38
18.0	14.65
20.0	14.15
22.0	13.78
24.0	13.50
26.0	13.28
28.0	13.11
30.0	12.97
32.0	12.86
34.0	12.77
36.0	12.69
38.0	12.62
40.0	12.57
42.0	12.52
44.0	12.48
46.0	12.44
48.0	12.41
50.0	12.38
52.0	12.36
54.0	12.34
56.0	12.32
58.0	12.30
60.0	12.29
65.0	12.26
70.0	12.24
75.0	12.22
80.0	12.21
85.0	12.21
90.0	12.21

BLUG—Derived Bottom Loss

Type 3

Figure A3. BLUG Province Type 3, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

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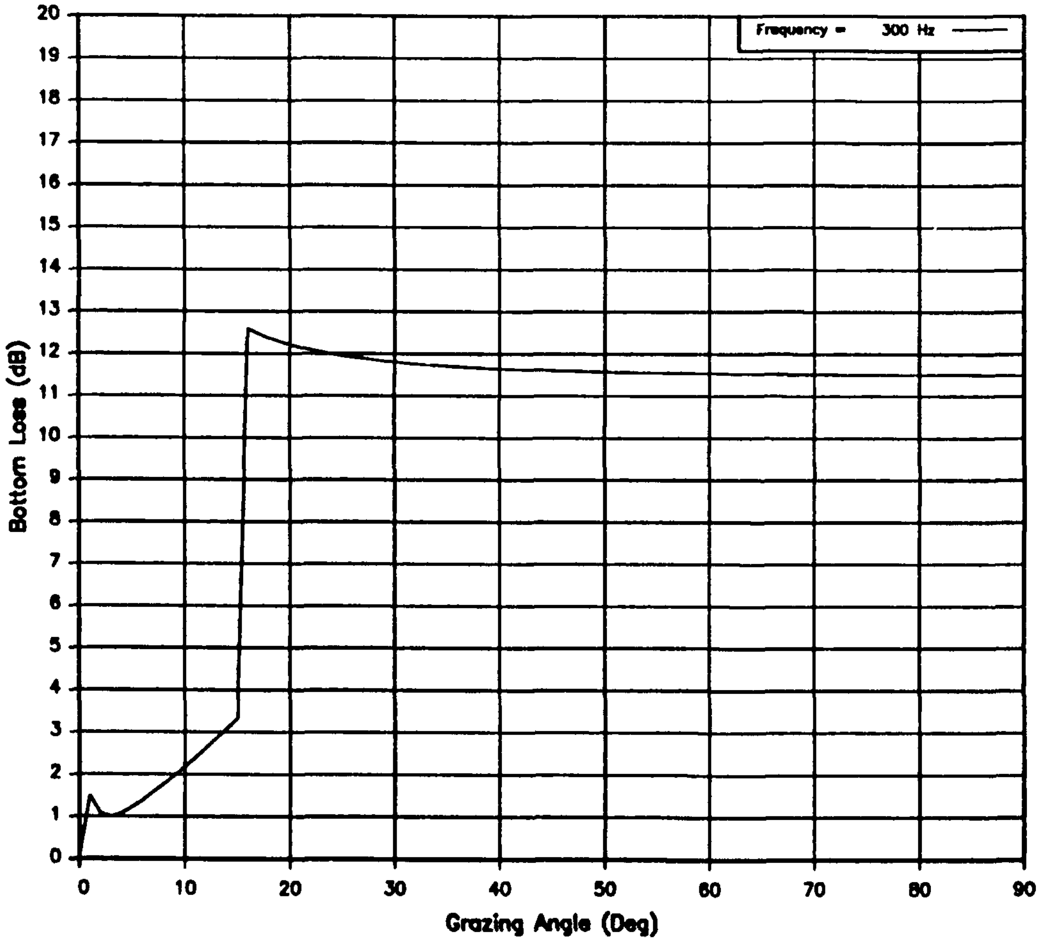


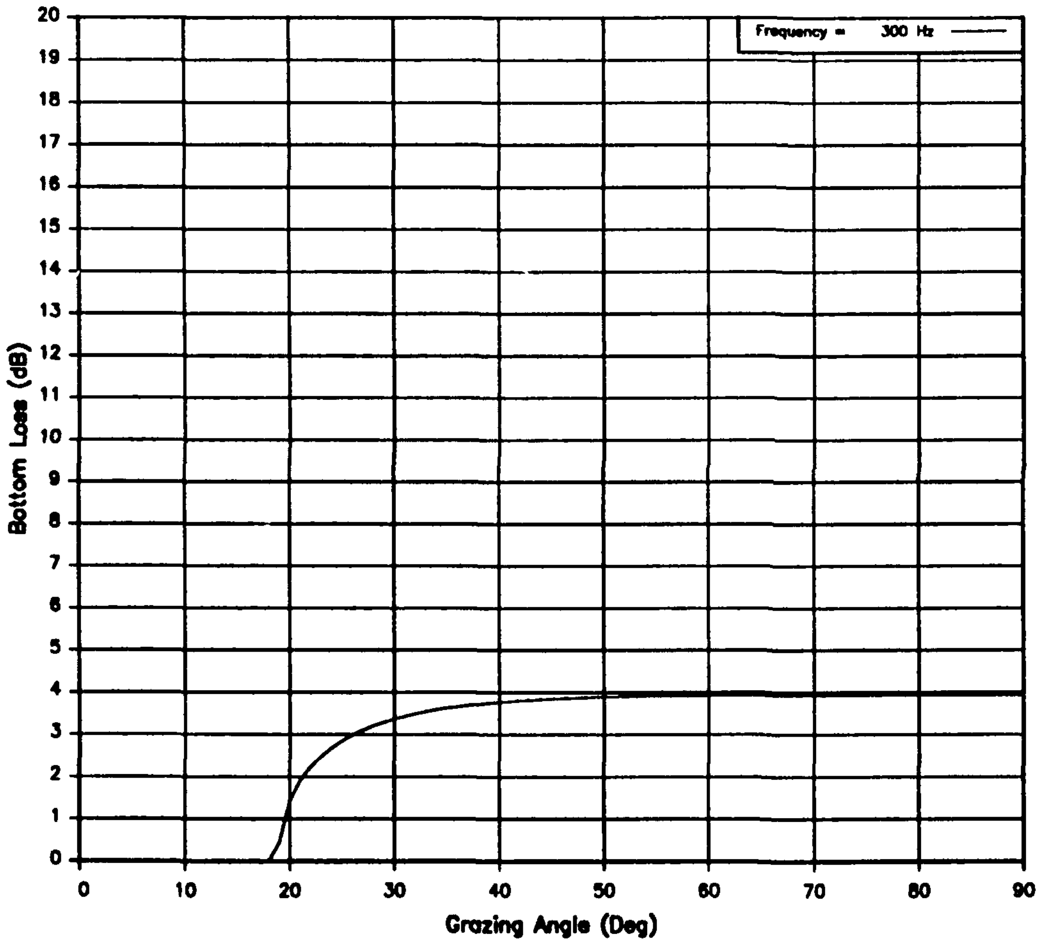
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.49
2.0	1.08
3.0	1.00
4.0	1.08
5.0	1.22
6.0	1.39
7.0	1.58
8.0	1.77
9.0	1.97
10.0	2.18
12.0	2.63
14.0	3.09
16.0	12.59
18.0	12.37
20.0	12.21
22.0	12.09
24.0	11.99
26.0	11.92
28.0	11.86
30.0	11.81
32.0	11.76
34.0	11.73
36.0	11.70
38.0	11.67
40.0	11.65
42.0	11.63
44.0	11.62
46.0	11.60
48.0	11.59
50.0	11.58
52.0	11.57
54.0	11.56
56.0	11.55
58.0	11.55
60.0	11.54
65.0	11.53
70.0	11.52
75.0	11.51
80.0	11.51
85.0	11.51
90.0	11.50

BLUG–Derived Bottom Loss

Type 4

Figure A4. BLUG Province Type 4, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline



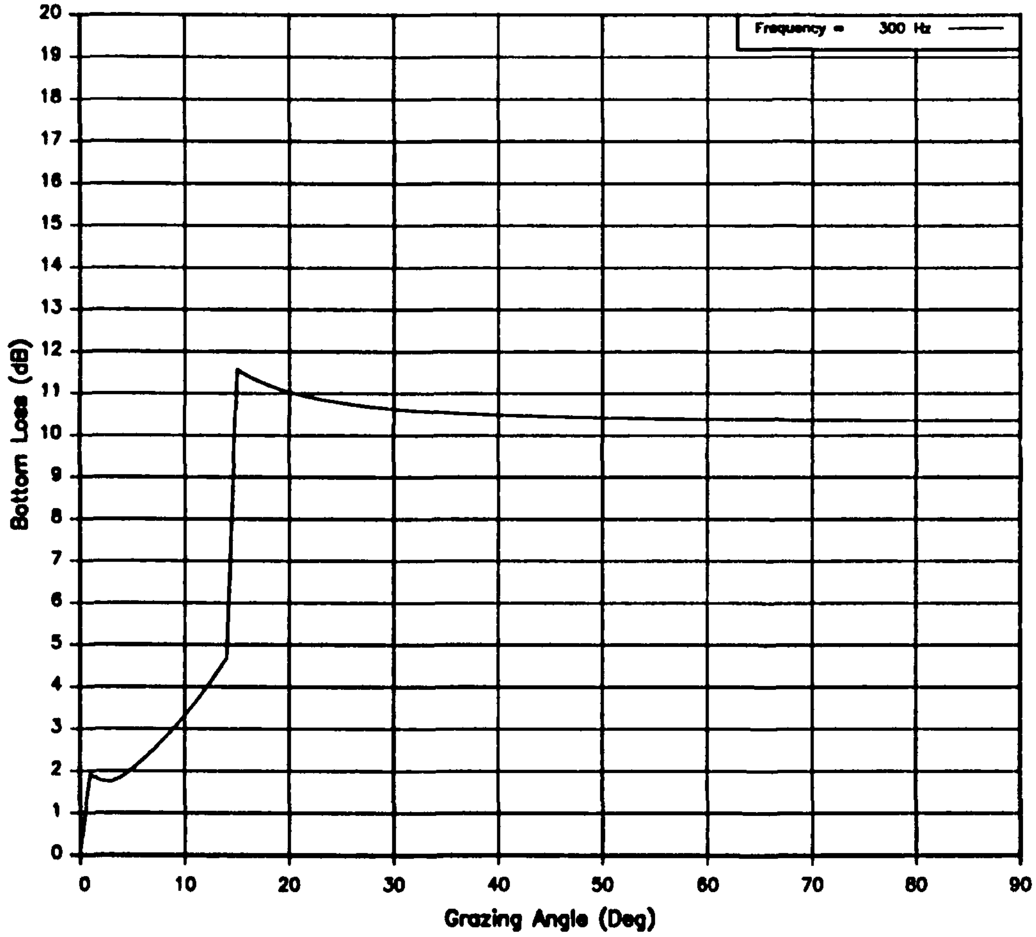
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.00
2.0	0.00
3.0	0.01
4.0	0.01
5.0	0.01
6.0	0.01
7.0	0.01
8.0	0.01
9.0	0.01
10.0	0.01
12.0	0.00
14.0	0.00
16.0	0.00
18.0	0.01
20.0	1.42
22.0	2.23
24.0	2.68
26.0	2.99
28.0	3.21
30.0	3.37
32.0	3.49
34.0	3.59
36.0	3.66
38.0	3.72
40.0	3.77
42.0	3.81
44.0	3.84
46.0	3.86
48.0	3.88
50.0	3.90
52.0	3.91
54.0	3.92
56.0	3.93
58.0	3.93
60.0	3.93
65.0	3.94
70.0	3.94
75.0	3.94
80.0	3.94
85.0	3.94
90.0	3.94

BLUG–Derived Bottom Loss

Type 5

Figure A5. BLUG Province Type 5, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline



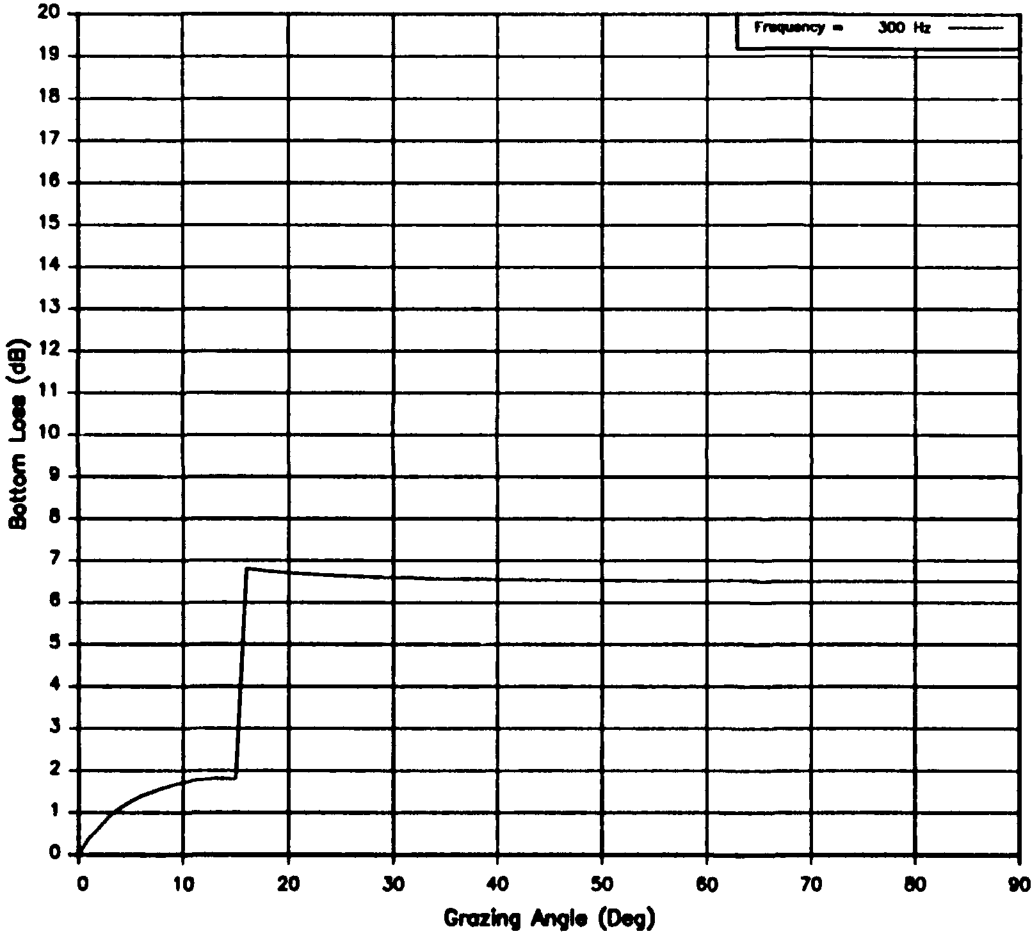
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.92
2.0	1.78
3.0	1.75
4.0	1.86
5.0	2.05
6.0	2.27
7.0	2.50
8.0	2.76
9.0	3.03
10.0	3.32
12.0	3.96
14.0	4.68
16.0	11.42
18.0	11.20
20.0	11.03
22.0	10.91
24.0	10.82
26.0	10.74
28.0	10.68
30.0	10.63
32.0	10.59
34.0	10.56
36.0	10.53
38.0	10.51
40.0	10.49
42.0	10.47
44.0	10.46
46.0	10.45
48.0	10.43
50.0	10.42
52.0	10.42
54.0	10.41
56.0	10.40
58.0	10.39
60.0	10.39
65.0	10.38
70.0	10.37
75.0	10.36
80.0	10.36
85.0	10.36
90.0	10.36

BLUG–Derived Bottom Loss

Type 6

Figure A6. BLUG Province Type 6, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.39
2.0	0.65
3.0	0.93
4.0	1.12
5.0	1.27
6.0	1.40
7.0	1.49
8.0	1.58
9.0	1.66
10.0	1.72
12.0	1.79
14.0	1.81
16.0	6.81
18.0	6.75
20.0	6.71
22.0	6.68
24.0	6.65
26.0	6.63
28.0	6.61
30.0	6.60
32.0	6.59
34.0	6.57
36.0	6.57
38.0	6.56
40.0	6.55
42.0	6.55
44.0	6.54
46.0	6.54
48.0	6.53
50.0	6.53
52.0	6.53
54.0	6.52
56.0	6.52
58.0	6.52
60.0	6.52
65.0	6.51
70.0	6.51
75.0	6.51
80.0	6.51
85.0	6.51
90.0	6.51

BLUG–Derived Bottom Loss

Type 7

Figure A7. BLUG Province Type 7, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

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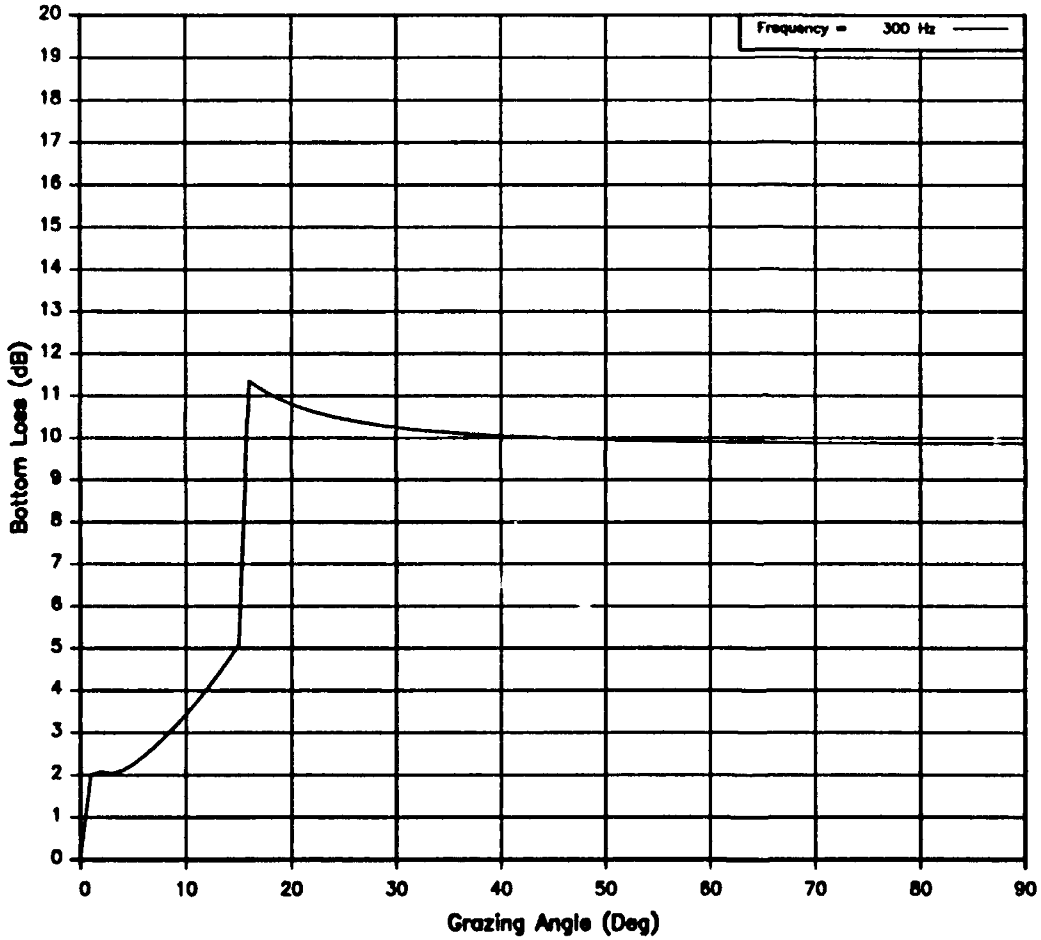


Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	2.01
2.0	2.07
3.0	2.03
4.0	2.11
5.0	2.26
6.0	2.45
7.0	2.67
8.0	2.91
9.0	3.17
10.0	3.44
12.0	4.04
14.0	4.72
16.0	11.35
18.0	11.03
20.0	10.80
22.0	10.63
24.0	10.50
26.0	10.40
28.0	10.32
30.0	10.25
32.0	10.19
34.0	10.15
36.0	10.11
38.0	10.08
40.0	10.05
42.0	10.03
44.0	10.01
46.0	9.99
48.0	9.97
50.0	9.96
52.0	9.95
54.0	9.94
56.0	9.93
58.0	9.92
60.0	9.91
65.0	9.90
70.0	9.88
75.0	9.88
80.0	9.87
85.0	9.87
90.0	9.87

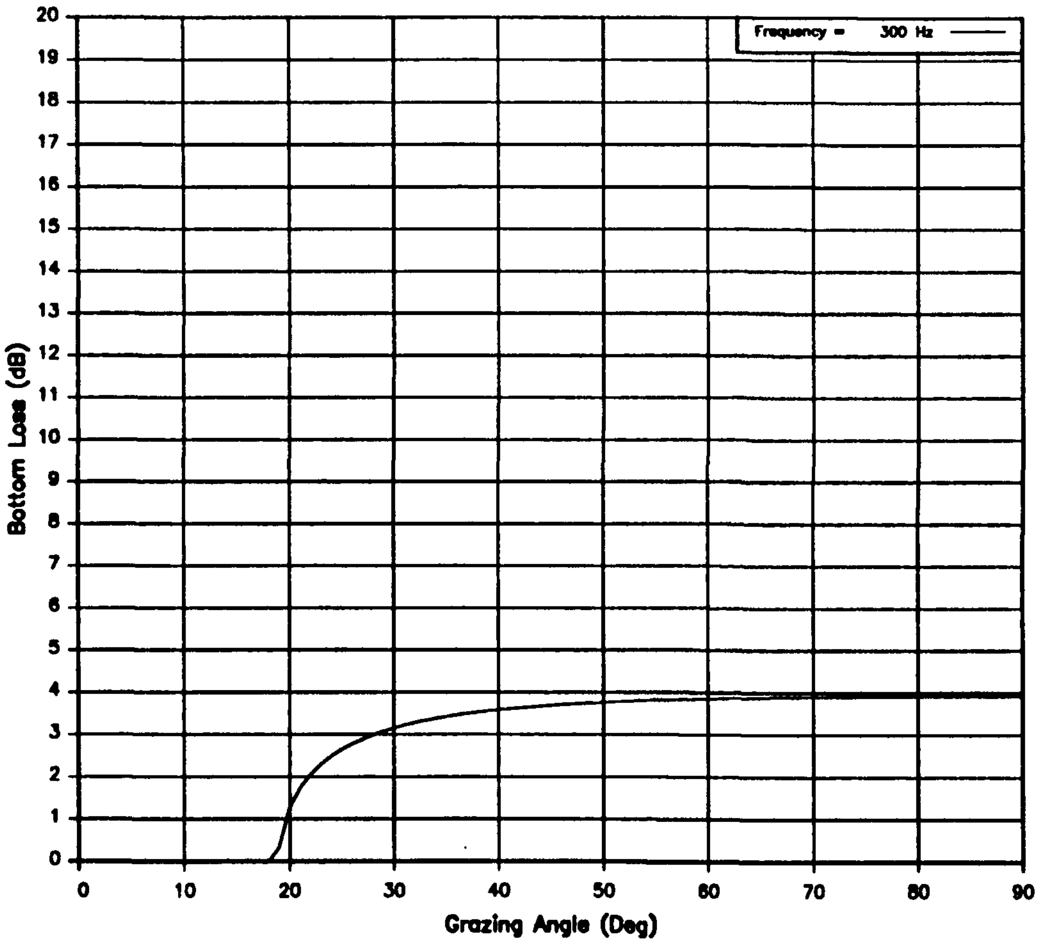
BLUG–Derived Bottom Loss

Type 8

Figure A8. BLUG Province Type 8, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

1-APR-92 07:48:08



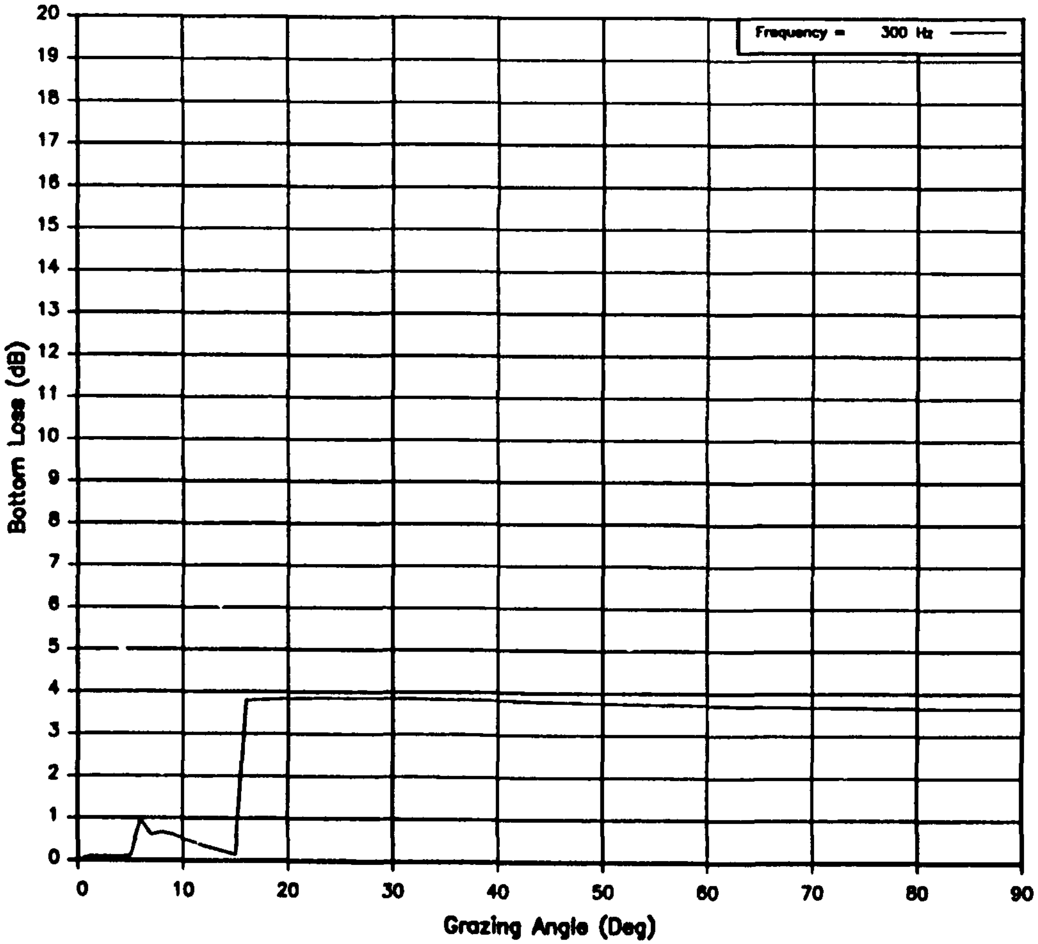
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.00
2.0	0.01
3.0	0.01
4.0	0.01
5.0	0.01
6.0	0.01
7.0	0.01
8.0	0.00
9.0	0.00
10.0	0.00
12.0	0.00
14.0	0.00
16.0	0.00
18.0	0.00
20.0	1.27
22.0	2.05
24.0	2.49
26.0	2.78
28.0	2.99
30.0	3.15
32.0	3.28
34.0	3.38
36.0	3.46
38.0	3.53
40.0	3.59
42.0	3.63
44.0	3.67
46.0	3.71
48.0	3.74
50.0	3.76
52.0	3.79
54.0	3.81
56.0	3.82
58.0	3.84
60.0	3.85
65.0	3.88
70.0	3.90
75.0	3.92
80.0	3.92
85.0	3.93
90.0	3.93

BLUG–Derived Bottom Loss

Type 9

Figure A9. BLUG Province Type 9, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.09
2.0	0.10
3.0	0.09
4.0	0.09
5.0	0.11
6.0	0.97
7.0	0.61
8.0	0.67
9.0	0.62
10.0	0.52
12.0	0.35
14.0	0.21
16.0	3.79
18.0	3.82
20.0	3.84
22.0	3.85
24.0	3.86
26.0	3.86
28.0	3.86
30.0	3.85
32.0	3.85
34.0	3.84
36.0	3.83
38.0	3.82
40.0	3.81
42.0	3.80
44.0	3.79
46.0	3.78
48.0	3.77
50.0	3.76
52.0	3.75
54.0	3.74
56.0	3.73
58.0	3.73
60.0	3.72
65.0	3.70
70.0	3.68
75.0	3.67
80.0	3.66
85.0	3.65
90.0	3.65

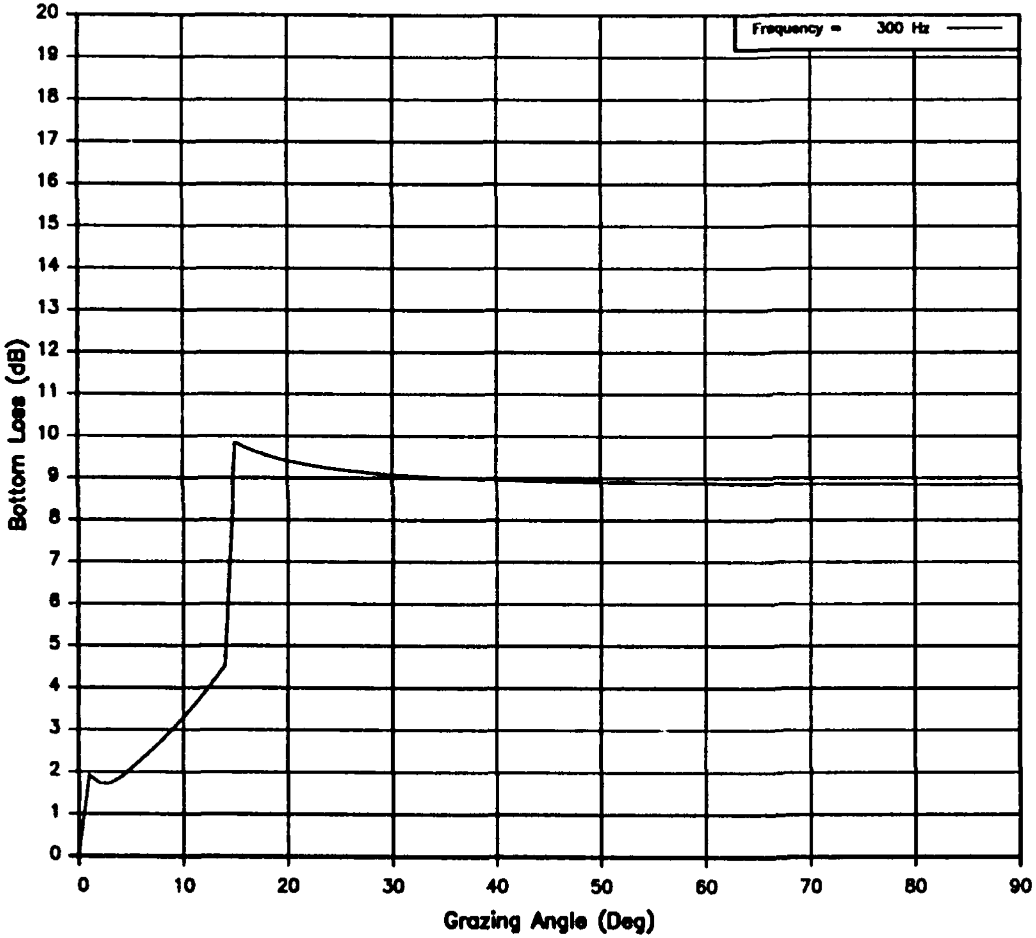
BLUG—Derived Bottom Loss

Type 10

Figure A10. BLUG Province Type 10, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

1-APR-92 07:30:15



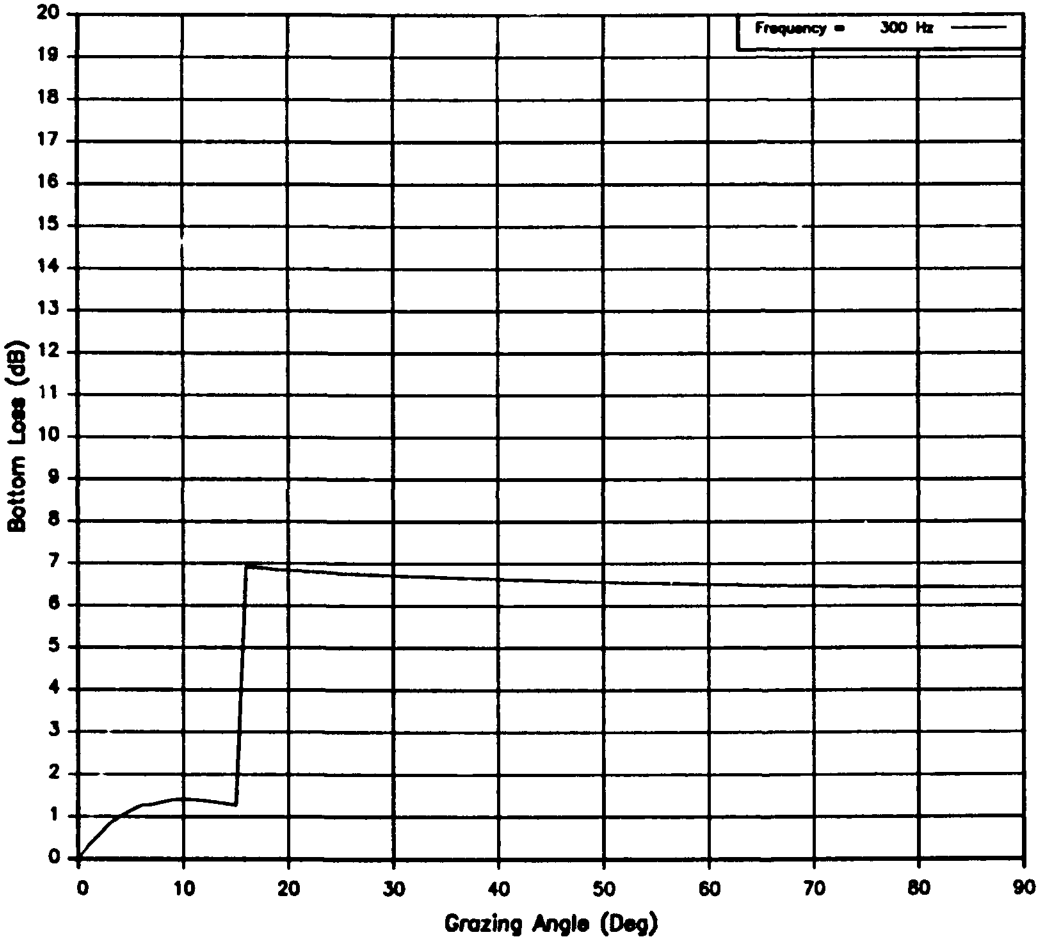
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.92
2.0	1.73
3.0	1.73
4.0	1.88
5.0	2.08
6.0	2.30
7.0	2.53
8.0	2.77
9.0	3.03
10.0	3.30
12.0	3.87
14.0	4.52
16.0	9.73
18.0	9.55
20.0	9.41
22.0	9.31
24.0	9.23
26.0	9.17
28.0	9.12
30.0	9.08
32.0	9.05
34.0	9.02
36.0	9.00
38.0	8.98
40.0	8.96
42.0	8.95
44.0	8.94
46.0	8.93
48.0	8.92
50.0	8.91
52.0	8.90
54.0	8.89
56.0	8.89
58.0	8.88
60.0	8.88
65.0	8.87
70.0	8.86
75.0	8.86
80.0	8.85
85.0	8.85
90.0	8.85

BLUG–Derived Bottom Loss

Type 11

Figure A11. BLUG Province Type 11, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline 1-APR-92 07:30:53



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.32
2.0	0.57
3.0	0.84
4.0	1.01
5.0	1.15
6.0	1.27
7.0	1.29
8.0	1.35
9.0	1.40
10.0	1.41
12.0	1.38
14.0	1.31
16.0	6.92
18.0	6.88
20.0	6.84
22.0	6.81
24.0	6.79
26.0	6.76
28.0	6.74
30.0	6.72
32.0	6.70
34.0	6.69
36.0	6.67
38.0	6.65
40.0	6.64
42.0	6.62
44.0	6.61
46.0	6.59
48.0	6.58
50.0	6.57
52.0	6.55
54.0	6.54
56.0	6.53
58.0	6.52
60.0	6.51
65.0	6.49
70.0	6.47
75.0	6.45
80.0	6.44
85.0	6.43
90.0	6.43

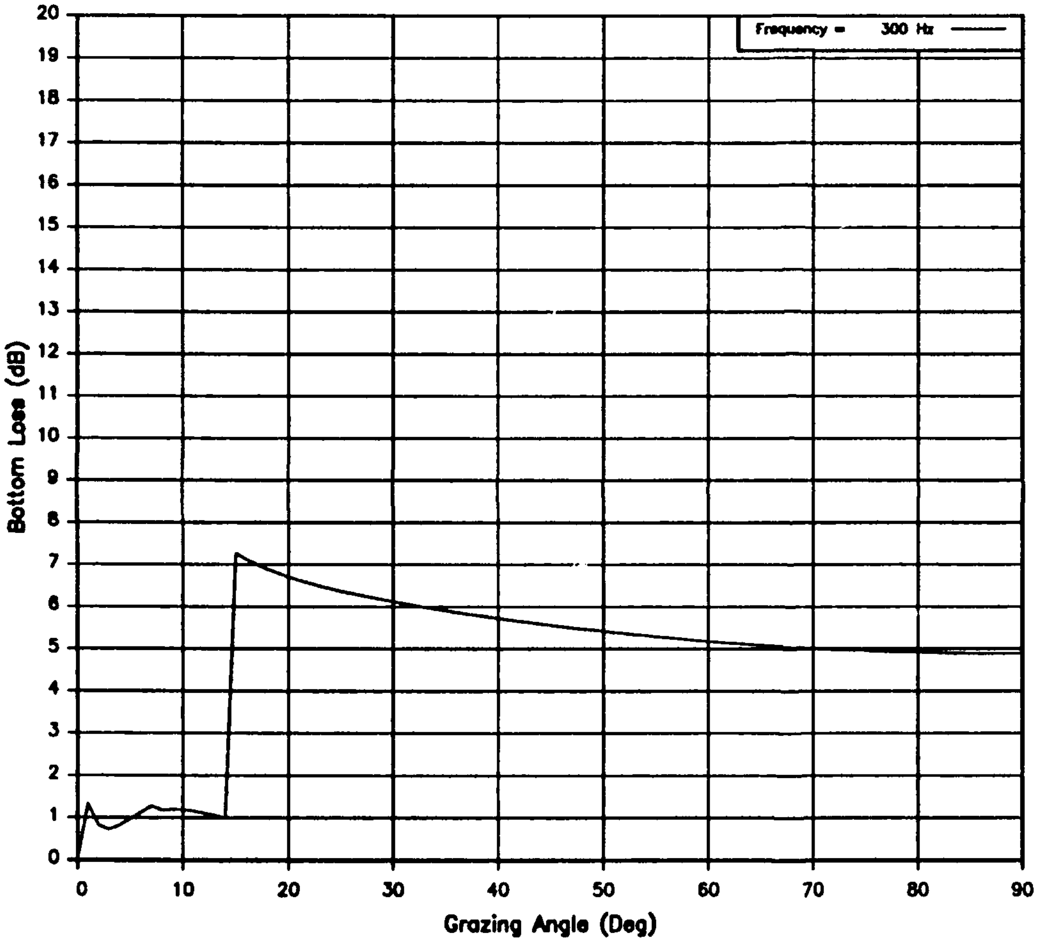
BLUG–Derived Bottom Loss

Type 12

Figure A12. BLUG Province Type 12, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

1-APR-92 07:51:33



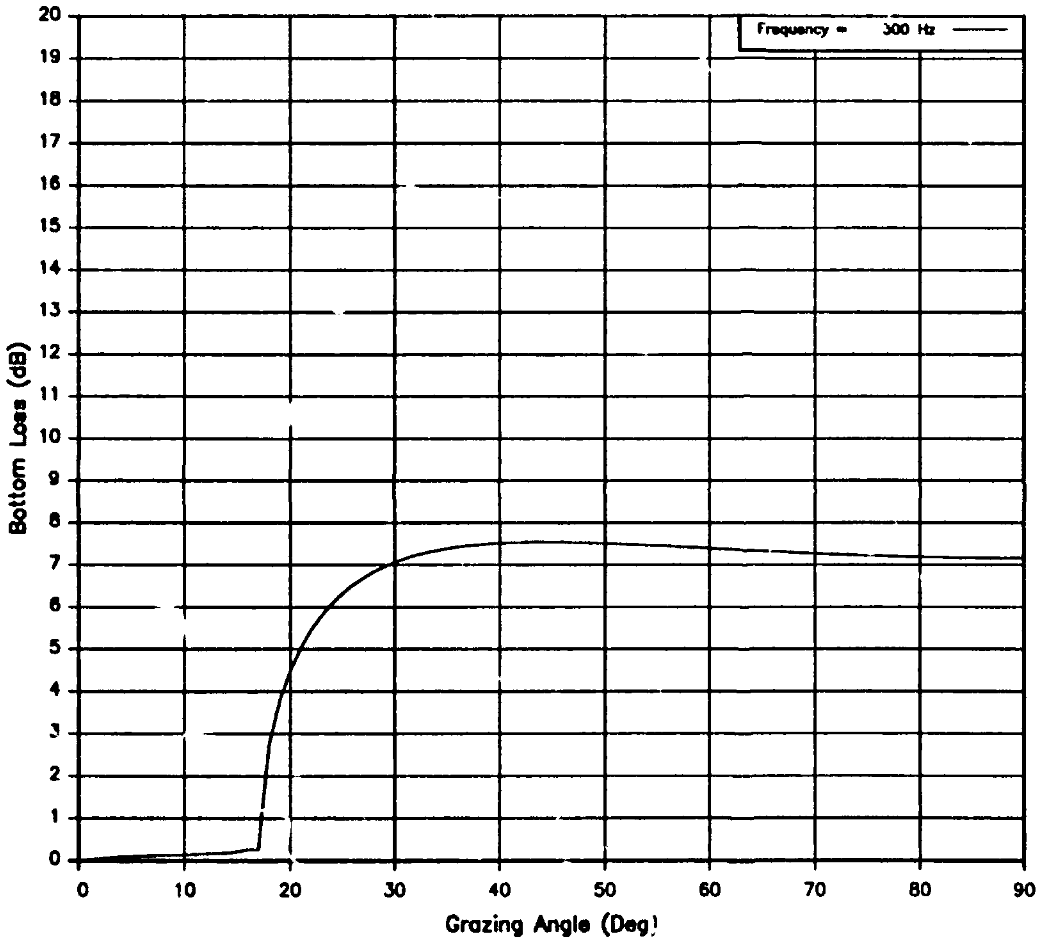
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.33
2.0	0.82
3.0	0.73
4.0	0.83
5.0	0.98
6.0	1.13
7.0	1.28
8.0	1.18
9.0	1.20
10.0	1.19
12.0	1.11
14.0	1.00
16.0	7.12
18.0	6.89
20.0	6.71
22.0	6.56
24.0	6.43
26.0	6.32
28.0	6.22
30.0	6.12
32.0	6.03
34.0	5.95
36.0	5.87
38.0	5.80
40.0	5.73
42.0	5.66
44.0	5.59
46.0	5.53
48.0	5.47
50.0	5.42
52.0	5.37
54.0	5.32
56.0	5.27
58.0	5.22
60.0	5.18
65.0	5.09
70.0	5.02
75.0	4.96
80.0	4.92
85.0	4.89
90.0	4.89

BLUG—Derived Bottom Loss

Type 13

Figure A13. BLUG Province Type 13, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline 1-APR-92 07:52:10



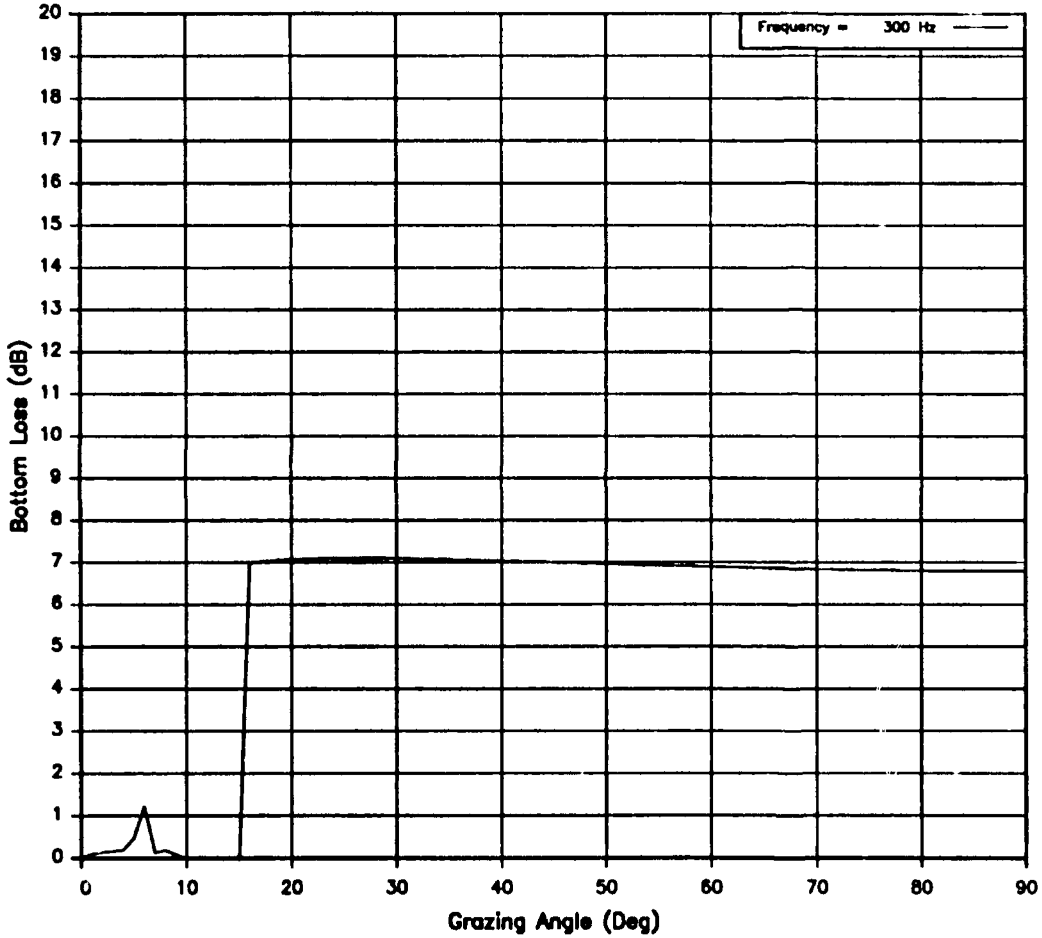
Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.03
2.0	0.05
3.0	0.07
4.0	0.09
5.0	0.10
6.0	0.11
7.0	0.12
8.0	0.13
9.0	0.13
10.0	0.14
12.0	0.16
14.0	0.18
16.0	0.26
18.0	2.73
20.0	4.49
22.0	5.46
24.0	6.09
26.0	6.53
28.0	6.84
30.0	7.06
32.0	7.23
34.0	7.34
36.0	7.43
38.0	7.48
40.0	7.52
42.0	7.53
44.0	7.54
46.0	7.54
48.0	7.53
50.0	7.51
52.0	7.49
54.0	7.47
56.0	7.45
58.0	7.42
60.0	7.39
65.0	7.33
70.0	7.27
75.0	7.22
80.0	7.19
85.0	7.17
90.0	7.16

BLUG–Derived Bottom Loss

Type 14

Figure A14. BLUG Province Type 14, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline 1-APR-92 07:52:48



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.10
2.0	0.14
3.0	0.16
4.0	0.19
5.0	0.48
6.0	1.22
7.0	0.13
8.0	0.19
9.0	0.08
10.0	0.00
12.0	0.00
14.0	0.00
16.0	6.99
18.0	7.04
20.0	7.08
22.0	7.09
24.0	7.10
26.0	7.10
28.0	7.10
30.0	7.09
32.0	7.08
34.0	7.07
36.0	7.06
38.0	7.05
40.0	7.04
42.0	7.02
44.0	7.01
46.0	6.99
48.0	6.98
50.0	6.96
52.0	6.95
54.0	6.93
56.0	6.92
58.0	6.91
60.0	6.90
65.0	6.87
70.0	6.84
75.0	6.82
80.0	6.81
85.0	6.80
90.0	6.80

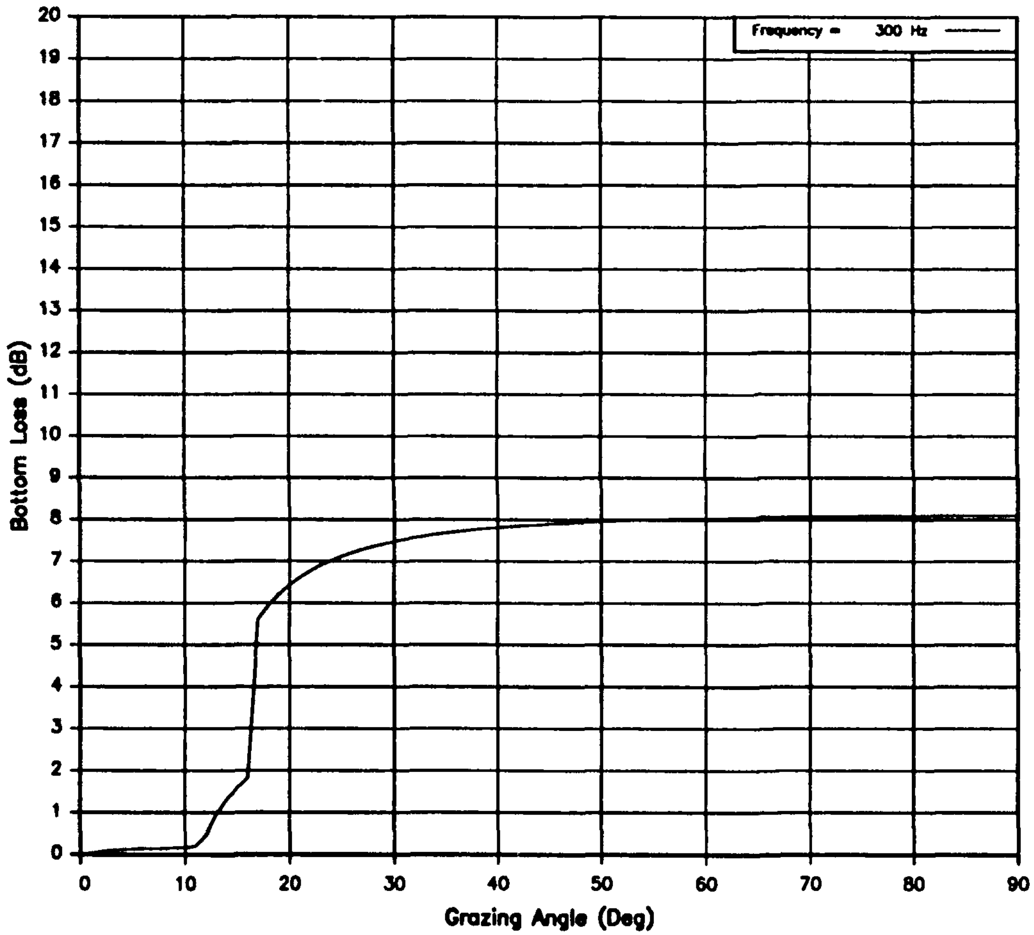
BLUG–Derived Bottom Loss

Type 15

Figure A15. BLUG Province Type 15, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

1-APR-92 07:53:28



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.04
2.0	0.07
3.0	0.10
4.0	0.12
5.0	0.13
6.0	0.14
7.0	0.14
8.0	0.15
9.0	0.16
10.0	0.17
12.0	0.47
14.0	1.32
16.0	1.83
18.0	5.94
20.0	6.43
22.0	6.77
24.0	7.02
26.0	7.21
28.0	7.36
30.0	7.48
32.0	7.57
34.0	7.65
36.0	7.71
38.0	7.77
40.0	7.81
42.0	7.85
44.0	7.88
46.0	7.91
48.0	7.94
50.0	7.96
52.0	7.98
54.0	7.99
56.0	8.01
58.0	8.02
60.0	8.03
65.0	8.06
70.0	8.07
75.0	8.09
80.0	8.09
85.0	8.10
90.0	8.10

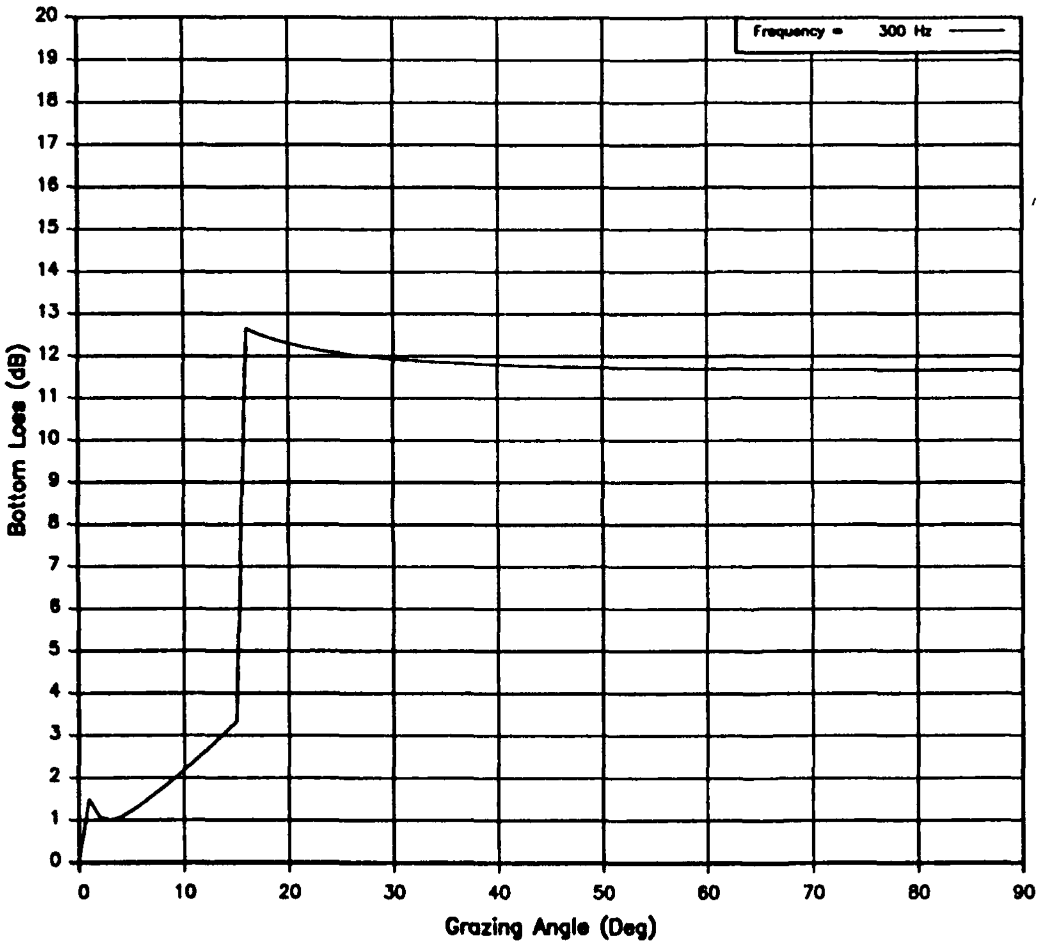
BLUG–Derived Bottom Loss

Type 16

Figure A16. BLUG Province Type 16, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

1-APR-92 07:54:08

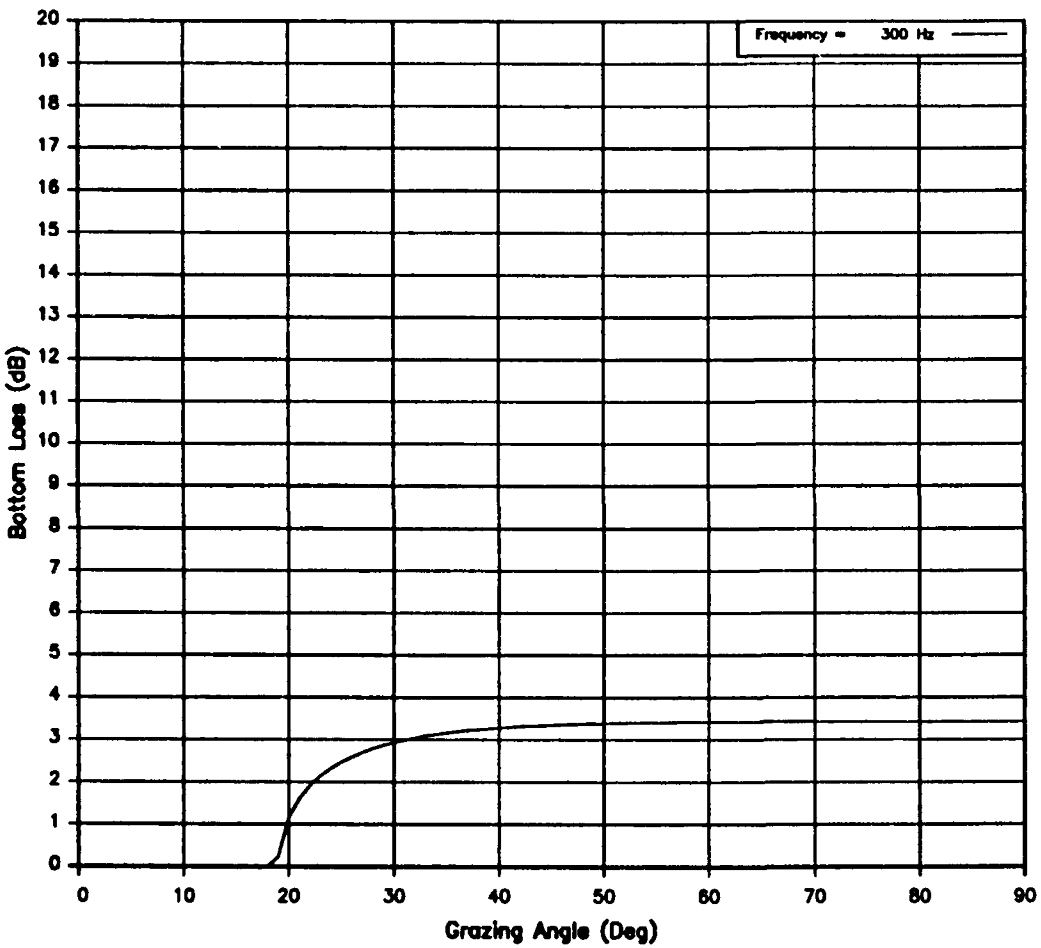


Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.49
2.0	1.08
3.0	1.00
4.0	1.08
5.0	1.22
6.0	1.39
7.0	1.58
8.0	1.77
9.0	1.97
10.0	2.18
12.0	2.63
14.0	3.10
16.0	12.65
18.0	12.45
20.0	12.30
22.0	12.19
24.0	12.10
26.0	12.03
28.0	11.98
30.0	11.93
32.0	11.90
34.0	11.86
36.0	11.84
38.0	11.82
40.0	11.80
42.0	11.78
44.0	11.77
46.0	11.75
48.0	11.74
50.0	11.73
52.0	11.72
54.0	11.72
56.0	11.71
58.0	11.70
60.0	11.70
65.0	11.69
70.0	11.68
75.0	11.68
80.0	11.67
85.0	11.67
90.0	11.67

BLUG–Derived Bottom Loss

Type 17

Figure A17. BLUG Province Type 17, Bottom Loss versus Grazing Angle



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	0.00
2.0	0.00
3.0	0.01
4.0	0.01
5.0	0.01
6.0	0.01
7.0	0.01
8.0	0.00
9.0	0.00
10.0	0.00
12.0	0.00
14.0	0.00
16.0	0.00
18.0	0.00
20.0	1.16
22.0	1.91
24.0	2.32
26.0	2.59
28.0	2.79
30.0	2.93
32.0	3.04
34.0	3.13
36.0	3.19
38.0	3.24
40.0	3.28
42.0	3.32
44.0	3.34
46.0	3.36
48.0	3.38
50.0	3.39
52.0	3.40
54.0	3.41
56.0	3.41
58.0	3.42
60.0	3.42
65.0	3.43
70.0	3.43
75.0	3.42
80.0	3.42
85.0	3.42
90.0	3.42

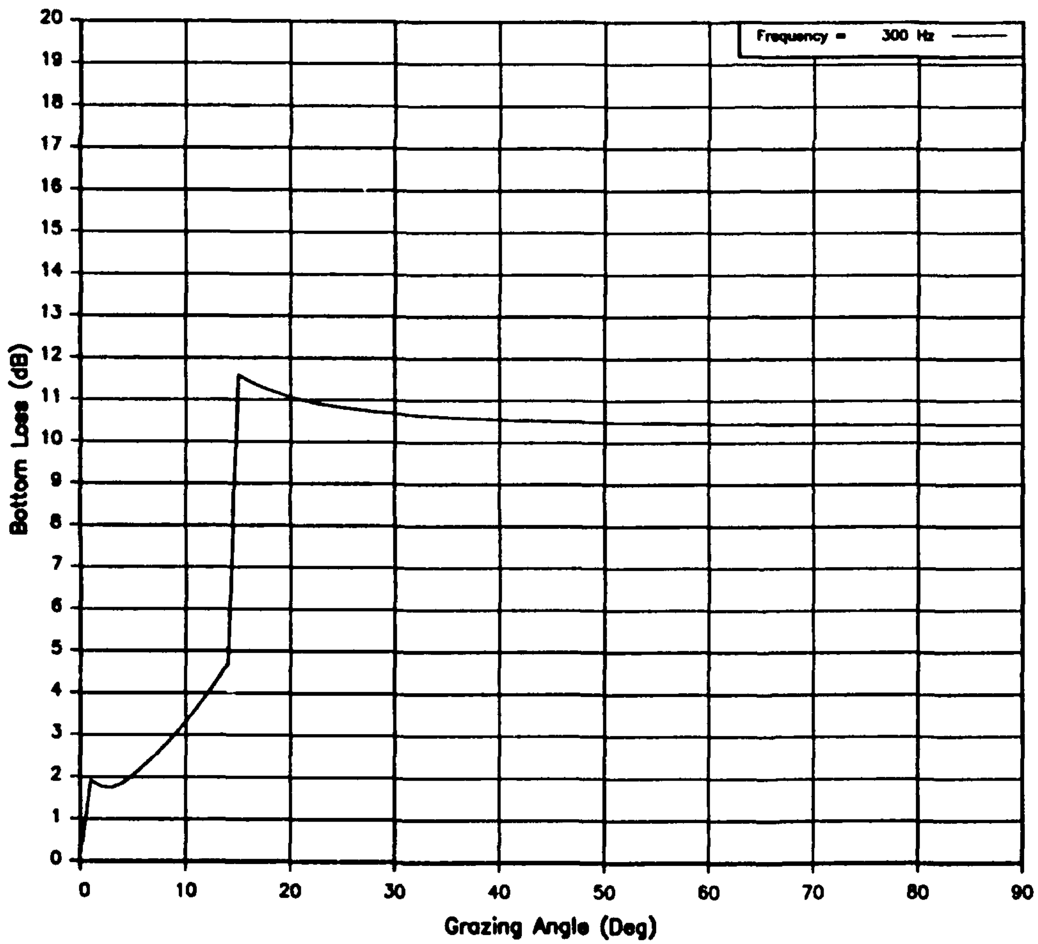
BLUG–Derived Bottom Loss

Type 18

Figure A18. BLUG Province Type 18, Bottom Loss versus Grazing Angle

TRW Acoustic Baseline

1-APR-92 07:06:22



Grazing Angle (Deg)	Loss (dB) 300 Hz
0.0	0.00
1.0	1.92
2.0	1.78
3.0	1.75
4.0	1.86
5.0	2.05
6.0	2.27
7.0	2.50
8.0	2.76
9.0	3.03
10.0	3.32
12.0	3.96
14.0	4.69
16.0	11.45
18.0	11.23
20.0	11.07
22.0	10.95
24.0	10.86
26.0	10.79
28.0	10.73
30.0	10.69
32.0	10.65
34.0	10.62
36.0	10.59
38.0	10.57
40.0	10.55
42.0	10.53
44.0	10.52
46.0	10.51
48.0	10.50
50.0	10.49
52.0	10.48
54.0	10.47
56.0	10.47
58.0	10.46
60.0	10.46
65.0	10.45
70.0	10.44
75.0	10.43
80.0	10.43
85.0	10.43
90.0	10.43

BLUG–Derived Bottom Loss

Type 19

Figure A19. BLUG Province Type 19, Bottom Loss versus Grazing Angle

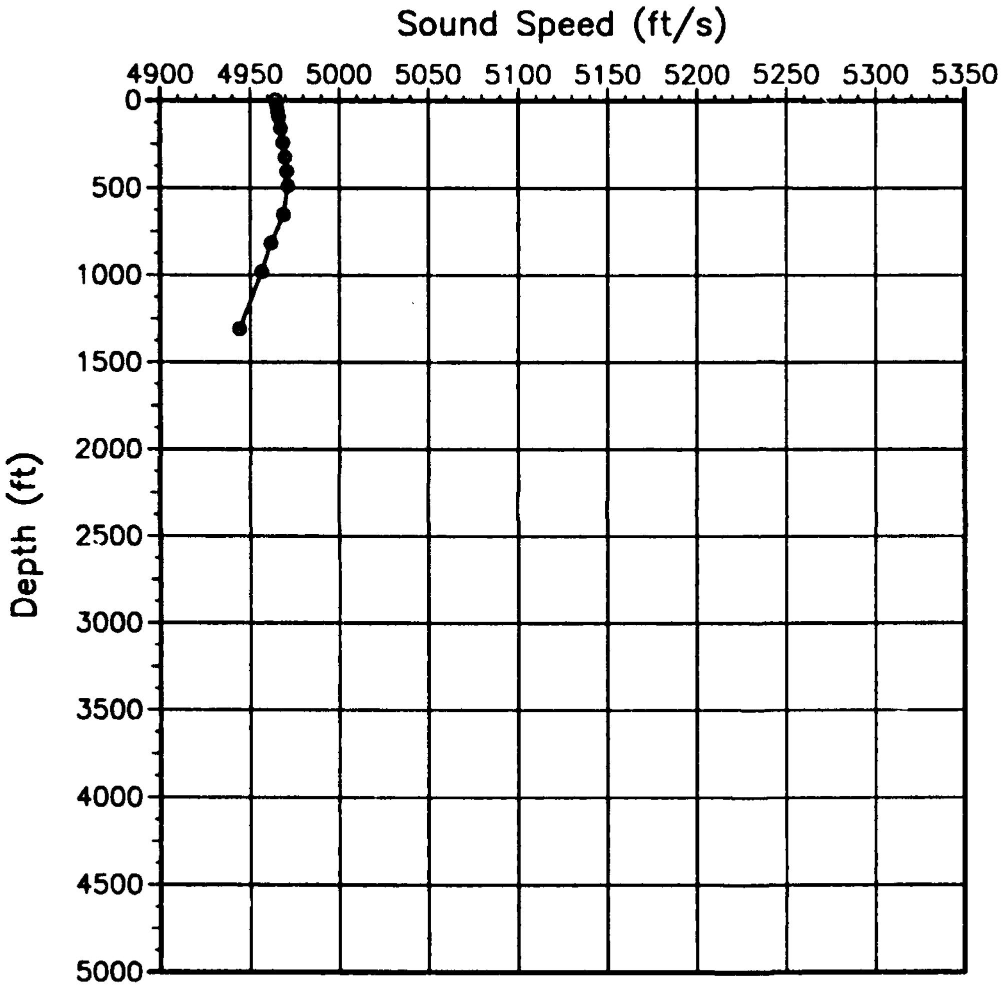
A.3 SOUND VELOCITY PROFILE

The sound velocity profile artificial data base was implemented similarly to the BLUG province data base descried above. Nineteen sound velocity profiles comprise the SVP data base. These profiles represent possible changes in the sound velocity profile that might occur in shallow water. These profiles are accessed by AUAMP. The sound velocity profile changes on every grid point. After the 19th access of the data base by AUAMP, the 1st sound velocity profile is used again, and the 19 profiles are cycled through again. Thus, differently resolved data bases used the same profile, yet with varying frequency.

The SVP artificial data bases were constructed to extend to a depth of approximately 1000 ft. Whenever the bottom depth for a specific run was shallower than the bottom depth, the SVP profile was cut off at the bottom depth. Figures A20 through A38 present plots of the 19 sound velocity profiles used. All the figures are extended out to approximately 1000 ft in depth.

TRW Acoustic Baseline

23-MAR-92 14:01:07



Depth (ft)	Speed (ft/s)
0.0	4964.3
32.8	4964.9
65.6	4965.4
98.4	4965.9
164.0	4967.0
246.1	4968.3
328.1	4969.6
410.1	4970.5
492.1	4971.1
656.2	4968.6
820.2	4961.5
984.3	4956.3
1312.3	4943.9

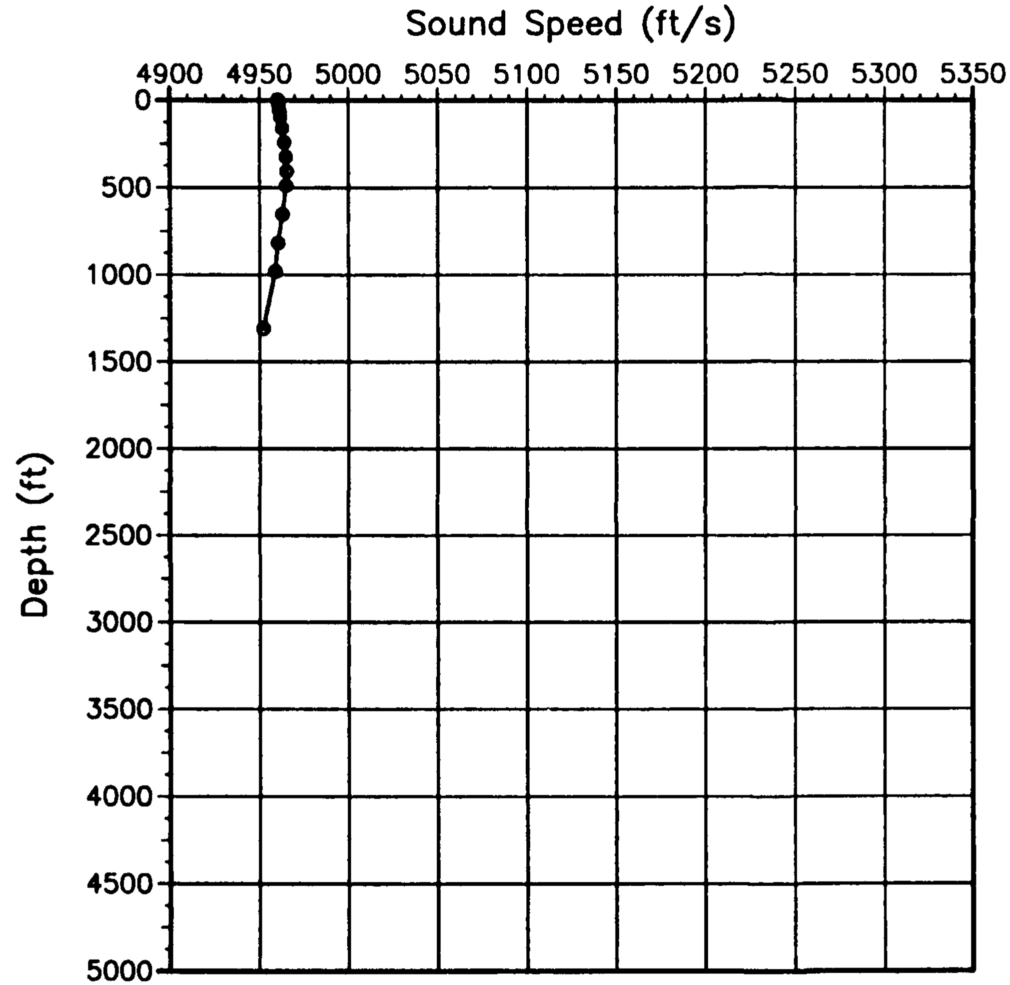
GDEM Sound Velocity Profile

SVP 1

Figure A20. Sound Velocity Profile Type 1

TRW Acoustic Baseline

23-MAR-92 14:01:30



Depth (ft)	Speed (ft/s)
0.0	4960.3
32.8	4960.7
65.6	4961.2
98.4	4961.6
164.0	4962.7
246.1	4963.8
328.1	4964.7
410.1	4965.1
492.1	4964.8
656.2	4962.7
820.2	4960.2
984.3	4958.7
1312.3	4951.9

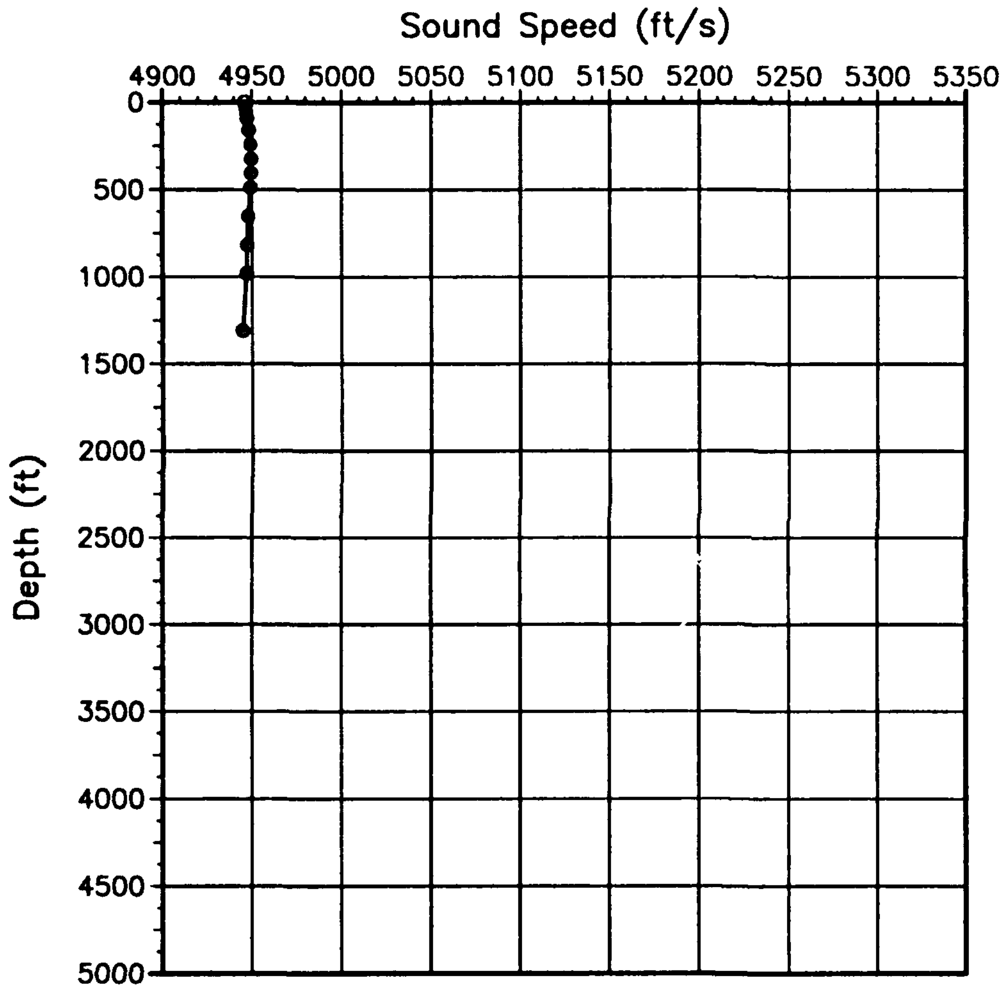
GDEM Sound Velocity Profile

SVP 2

Figure A21. Sound Velocity Profile Type 2

TRW Acoustic Baseline

23-MAR-92 14:02:08



Depth (ft)	Speed (ft/s)
0.0	4945.9
32.8	4946.4
65.6	4946.9
98.4	4947.3
164.0	4948.2
246.1	4949.0
328.1	4949.5
410.1	4949.5
492.1	4949.2
656.2	4948.0
820.2	4947.3
984.3	4947.0
1312.3	4944.7

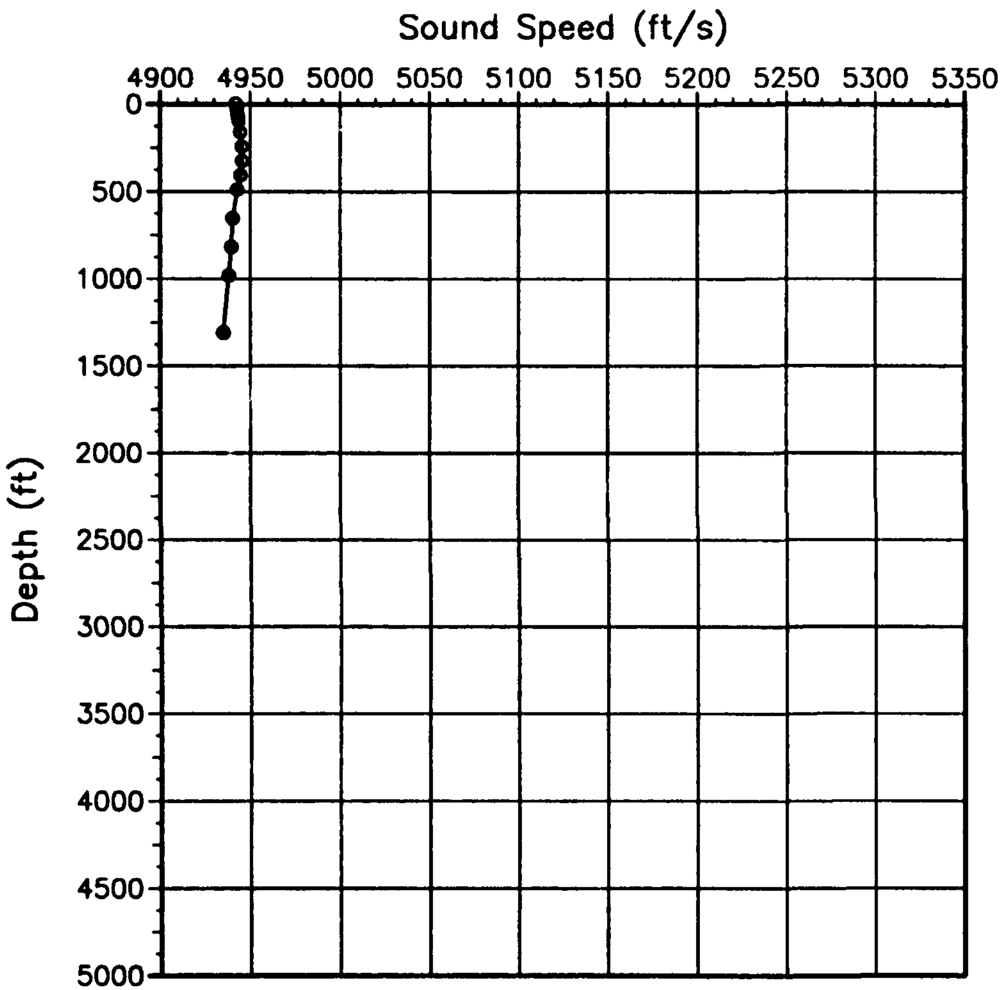
GDEM Sound Velocity Profile

SVP 3

Figure A22. Sound Velocity Profile Type 3

TRW Acoustic Baseline

23-MAR-92 14:02:41

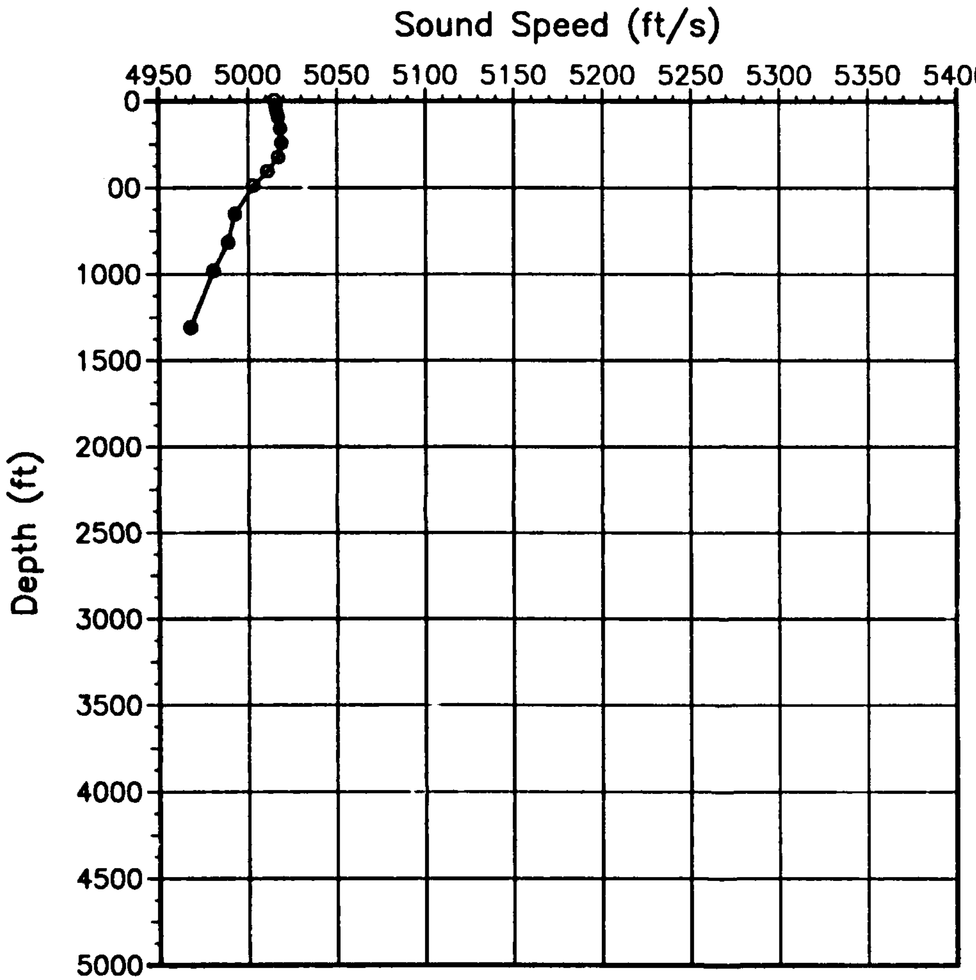


Depth (ft)	Speed (ft/s)
0.0	4941.8
32.8	4942.4
65.6	4942.9
98.4	4943.4
164.0	4944.3
246.1	4945.2
328.1	4945.4
410.1	4944.5
492.1	4942.7
656.2	4940.1
820.2	4939.4
984.3	4937.9
1312.3	4934.9

GDEM Sound Velocity Profile

SVP 4

Figure A23. Sound Velocity Profile Type 4



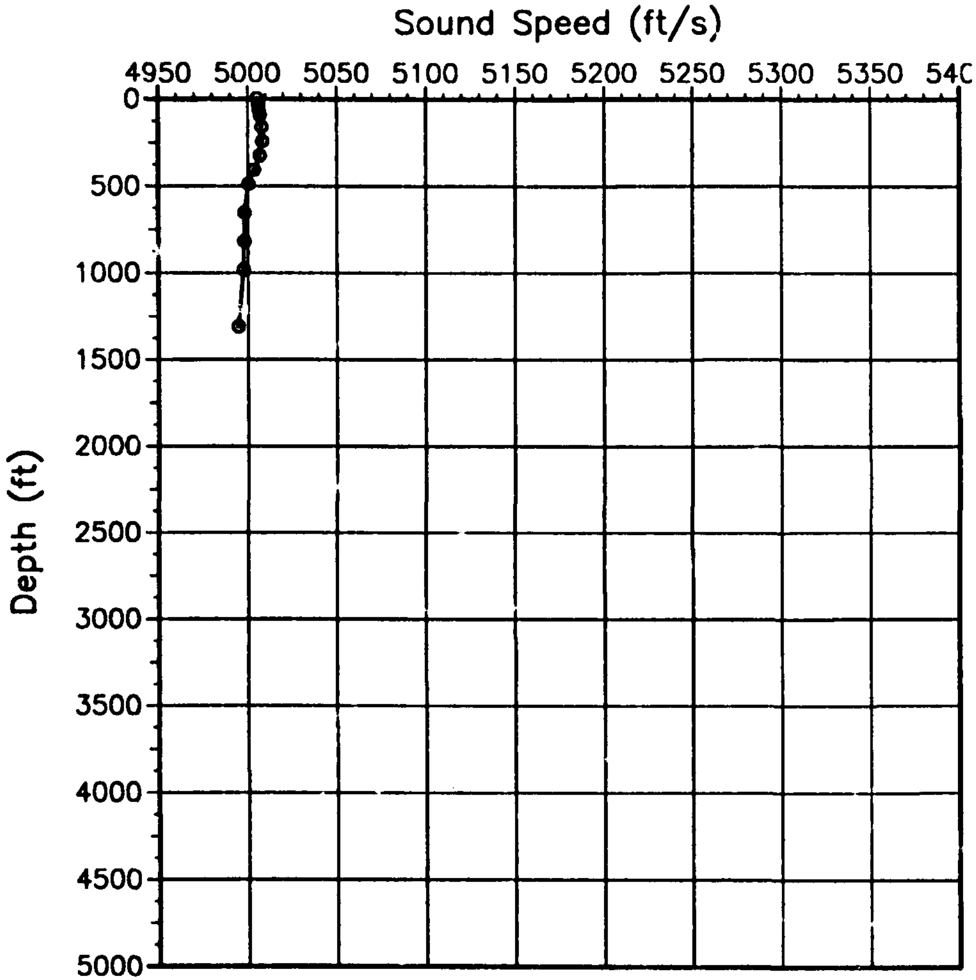
Depth (ft)	Speed (ft/s)
0.0	5014.7
32.8	5015.5
65.6	5016.0
98.4	5016.8
164.0	5018.0
246.1	5018.6
328.1	5016.7
410.1	5010.7
492.1	5002.7
656.2	4992.5
820.2	4988.6
984.3	4980.3
1312.3	4967.5

GDEM Sound Velocity Profile

SVP 5

Figure A24. Sound Velocity Profile Type 5

TRW Acoustic Baseline 23-MAR-92 14:03:42



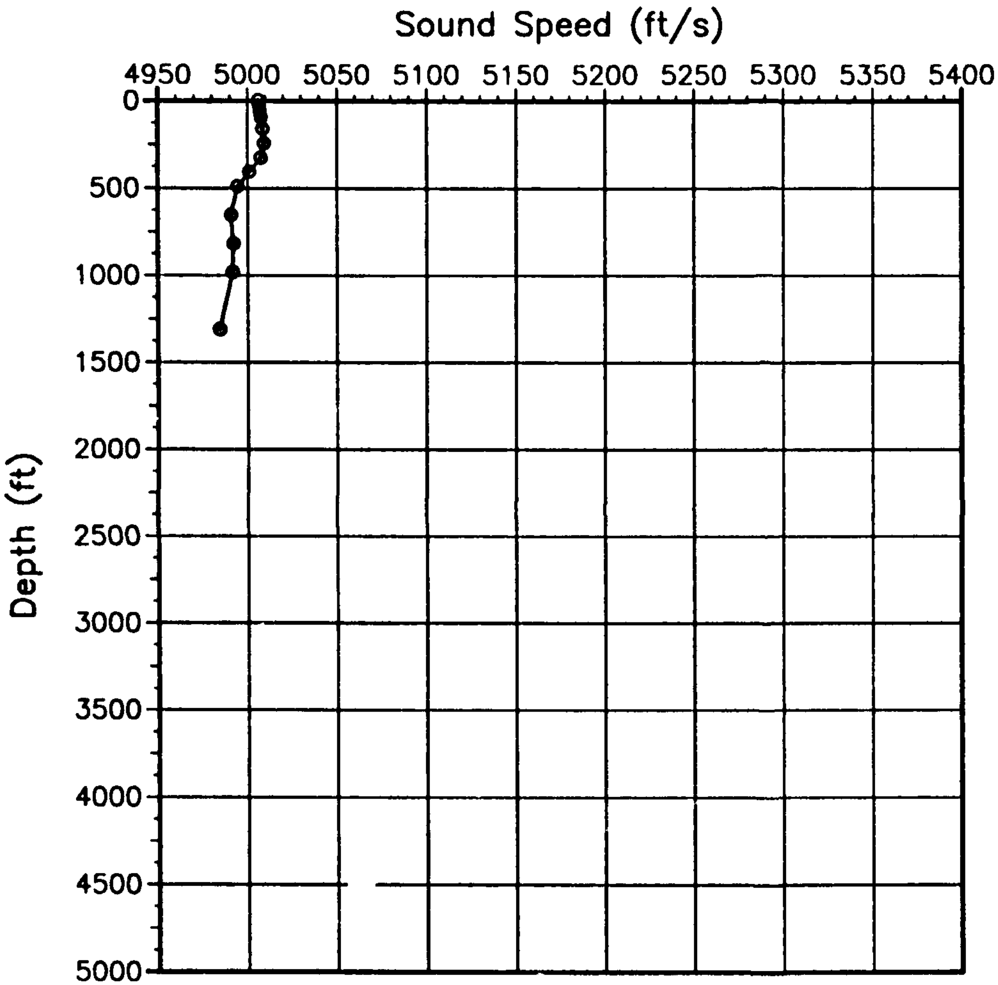
Depth (ft)	Speed (ft/s)
0.0	5005.1
32.8	5005.7
65.6	5006.3
98.4	5006.8
164.0	5007.7
246.1	5008.1
328.1	5006.7
410.1	5003.4
492.1	5000.3
656.2	4998.0
820.2	4997.9
984.3	4997.5
1312.3	4994.6

GDEM Sound Velocity Profile

SVP 6

Figure A25. Sound Velocity Profile Type 6

TRW Acoustic Baseline 23-MAR-92 14:04:14



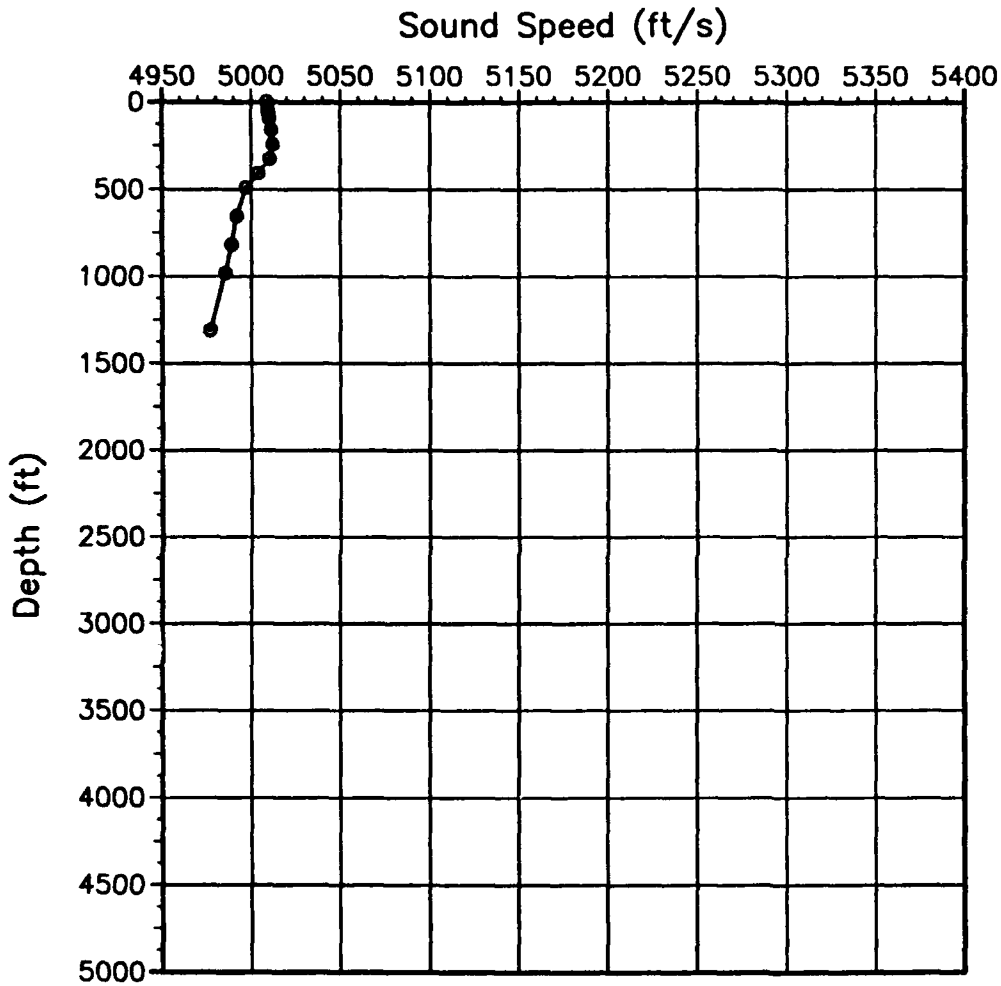
Depth (ft)	Speed (ft/s)
0.0	5006.0
32.8	5006.5
65.6	5006.9
98.4	5007.4
164.0	5008.4
246.1	5009.1
328.1	5007.3
410.1	5000.9
492.1	4994.4
656.2	4990.6
820.2	4992.0
984.3	4991.5
1312.3	4984.3

GDEM Sound Velocity Profile

SVP 7

Figure A26. Sound Velocity Profile Type 7

TRW Acoustic Baseline



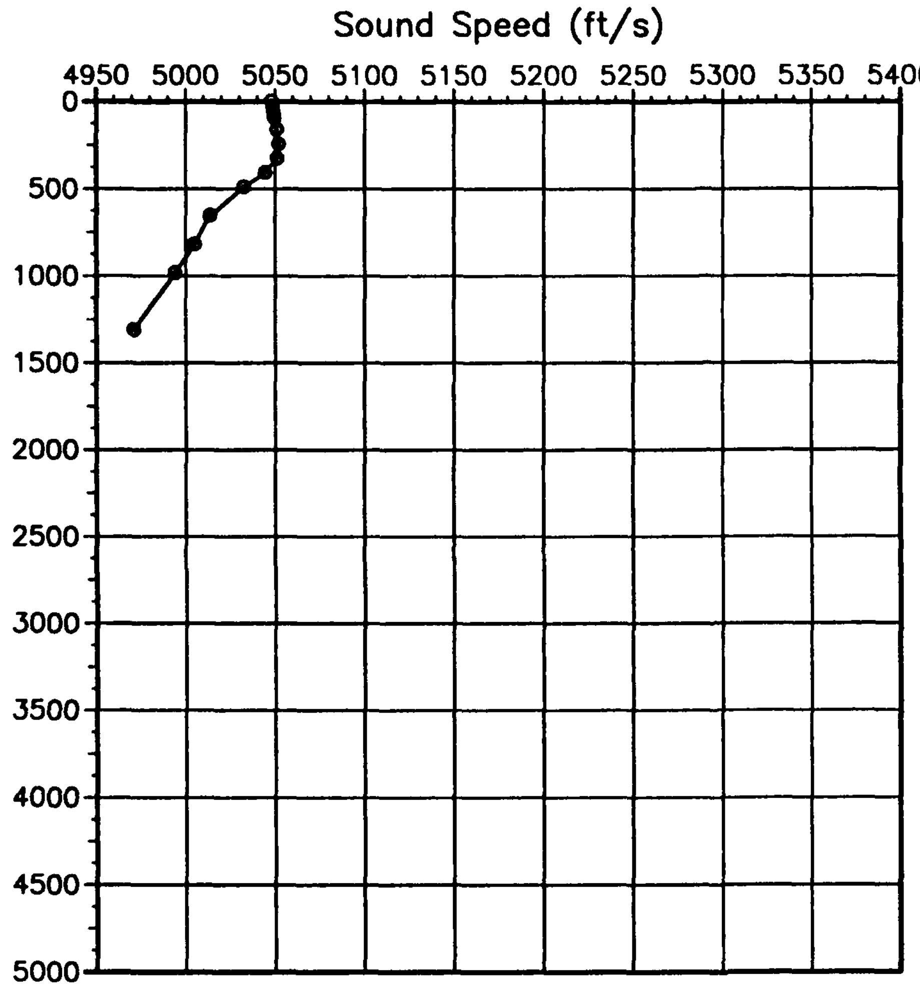
Depth (ft)	Speed (ft/s)
0.0	5008.6
32.8	5009.2
65.6	5009.8
98.4	5010.2
164.0	5011.3
246.1	5011.9
328.1	5010.2
410.1	5004.0
492.1	4997.0
656.2	4991.7
820.2	4988.7
984.3	4985.1
1312.3	4976.7

GDEM Sound Velocity Profile

SVP 8

Figure A27. Sound Velocity Profile Type 8

TRW Acoustic Baseline 23-MAR-92 14:05:18



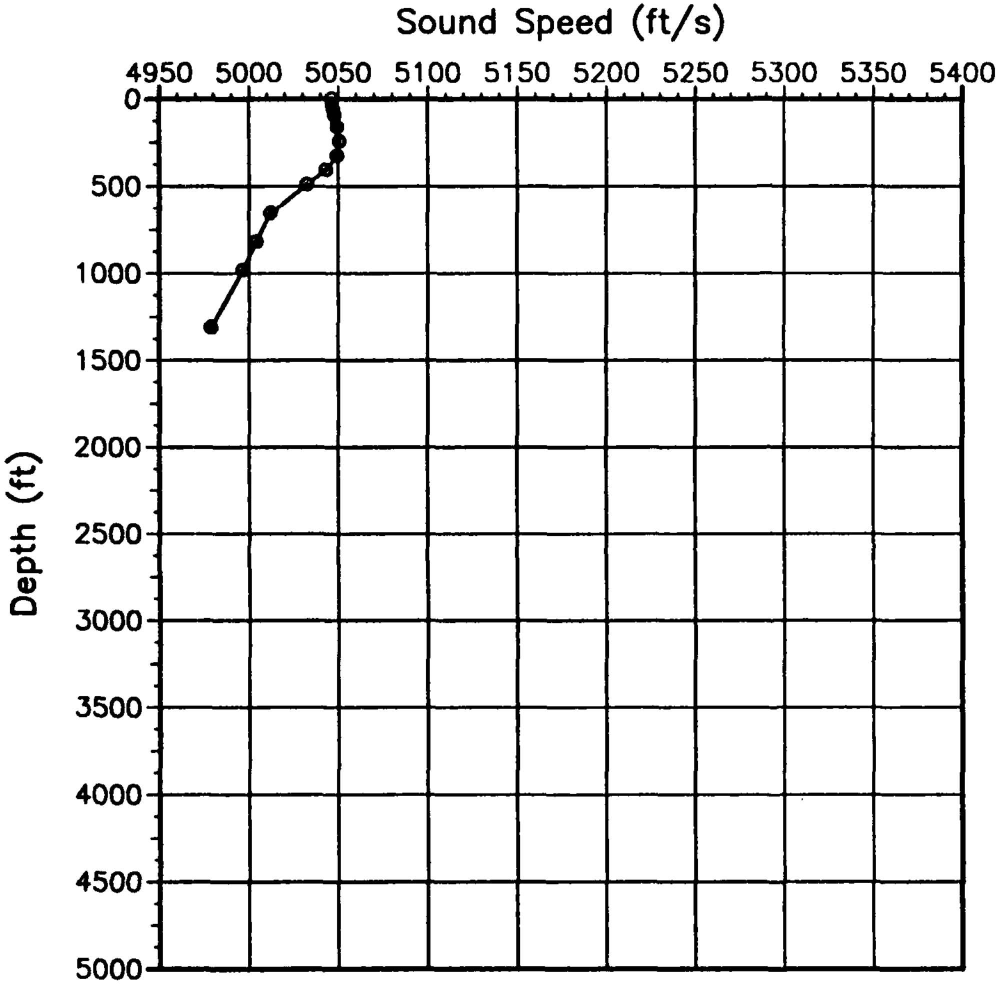
Depth (ft)	Speed (ft/s)
0.0	5047.8
32.8	5048.3
65.6	5048.8
98.4	5049.2
164.0	5050.6
246.1	5052.0
328.1	5051.0
410.1	5044.3
492.1	5032.2
656.2	5013.4
820.2	5004.8
984.3	4993.9
1312.3	4970.8

GDEM Sound Velocity Profile

SVP 9

Figure A28. Sound Velocity Profile Type 9

TRW Acoustic Baseline 27-MAR-92 11:18:00



Depth (ft)	Speed (ft/s)
0.0	5046.1
32.8	5046.5
65.6	5047.2
98.4	5047.9
164.0	5049.3
246.1	5050.5
328.1	5049.1
410.1	5043.0
492.1	5032.2
656.2	5012.1
820.2	5004.1
984.3	4996.5
1312.3	4978.6

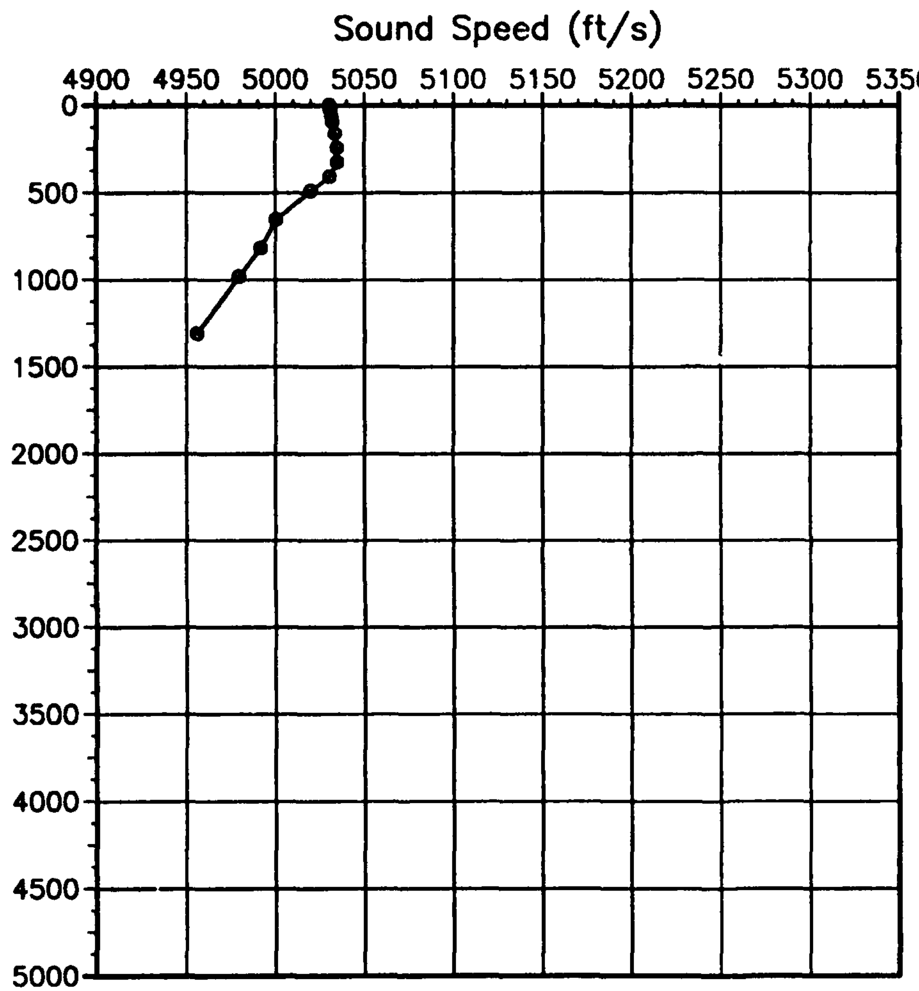
GDEM Sound Velocity Profile

SVP 10

Figure A29. Sound Velocity Profile Type 10

TRW Acoustic Baseline

23-MAR-92 14:08:24



Depth (ft)	Speed (ft/s)
0.0	5030.2
32.8	5030.7
65.6	5031.3
98.4	5031.9
164.0	5033.2
246.1	5034.6
328.1	5034.7
410.1	5030.5
492.1	5019.8
656.2	5000.0
820.2	4991.7
984.3	4979.3
1312.3	4955.6

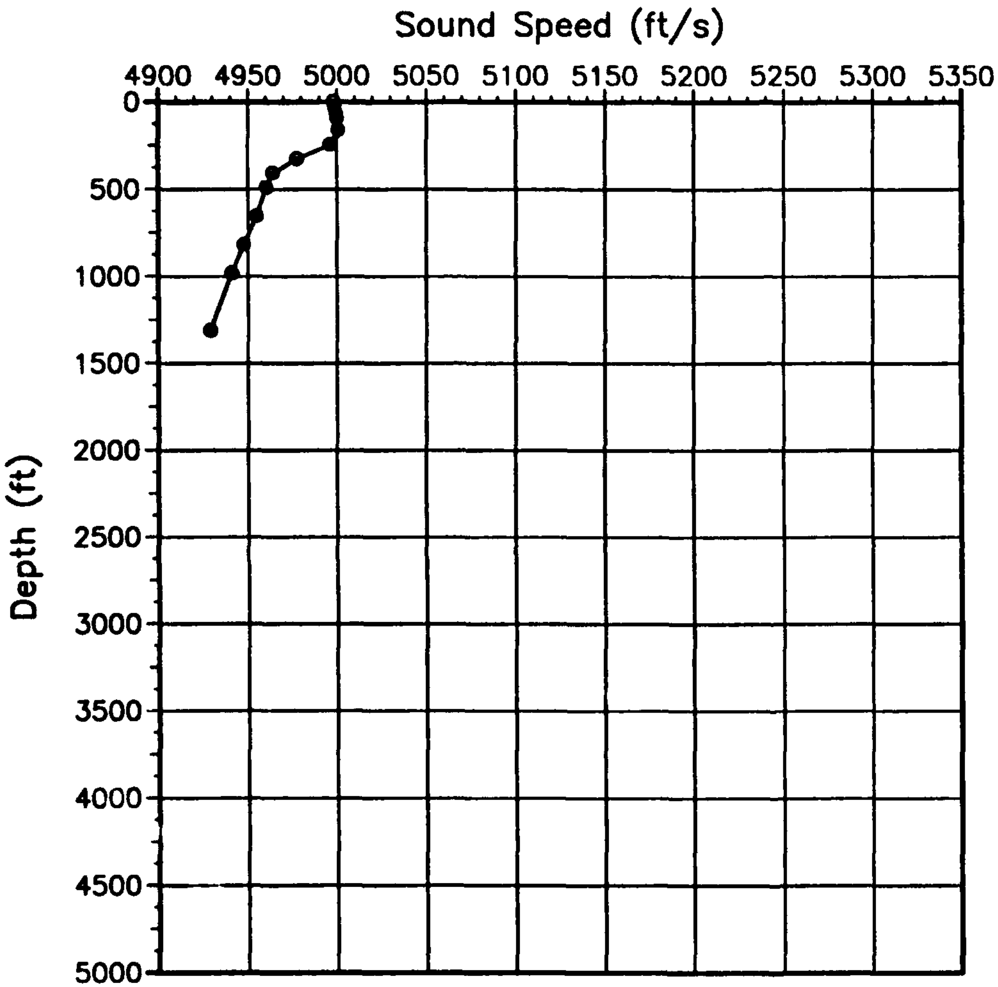
GDEM Sound Velocity Profile

SVP 11

Figure A30. Sound Velocity Profile Type 11

TRW Acoustic Baseline

23-MAR-92 14:06:53

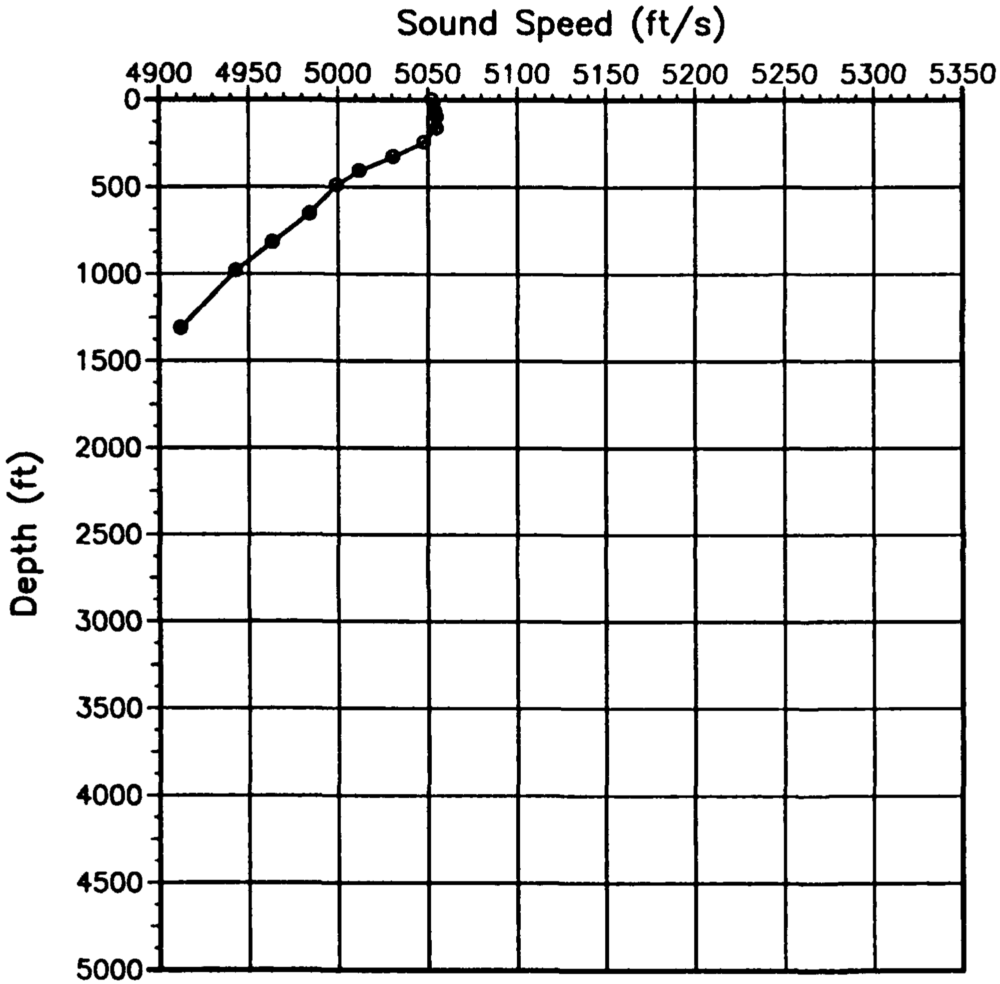


Depth (ft)	Speed (ft/s)
0.0	4997.8
32.8	4998.5
65.6	4999.1
98.4	4999.7
164.0	5000.4
246.1	4996.0
328.1	4977.5
410.1	4963.8
492.1	4960.2
656.2	4954.6
820.2	4947.6
984.3	4940.7
1312.3	4928.6

GDEM Sound Velocity Profile

SVP 12

Figure A31. Sound Velocity Profile Type 12



Depth (ft)	Speed (ft/s)
0.0	5052.0
32.8	5053.1
65.6	5054.0
98.4	5054.8
164.0	5054.9
246.1	5047.6
328.1	5030.4
410.1	5011.7
492.1	4998.9
656.2	4984.0
820.2	4963.2
984.3	4942.5
1312.3	4911.8

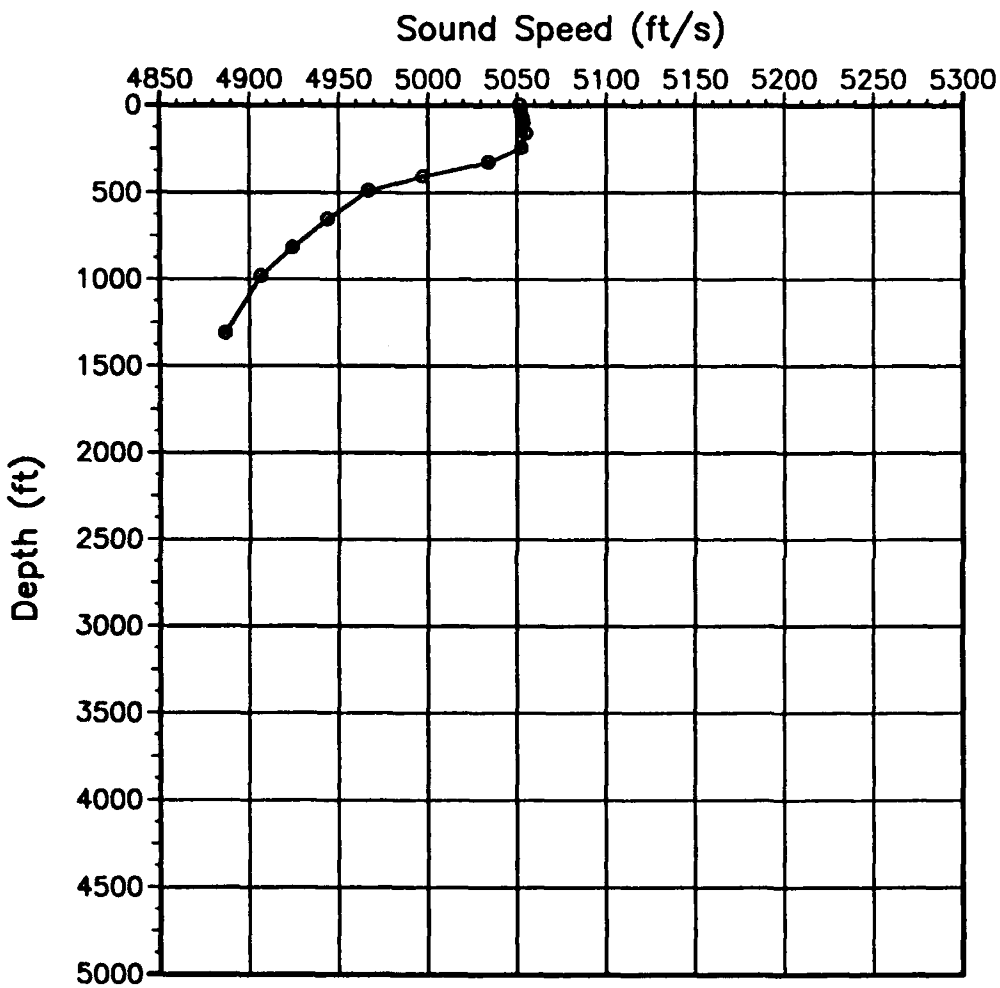
GDEM Sound Velocity Profile

SVP 13

Figure A32. Sound Velocity Profile Type 13

TRW Acoustic Baseline

23-MAR-92 14:07:32



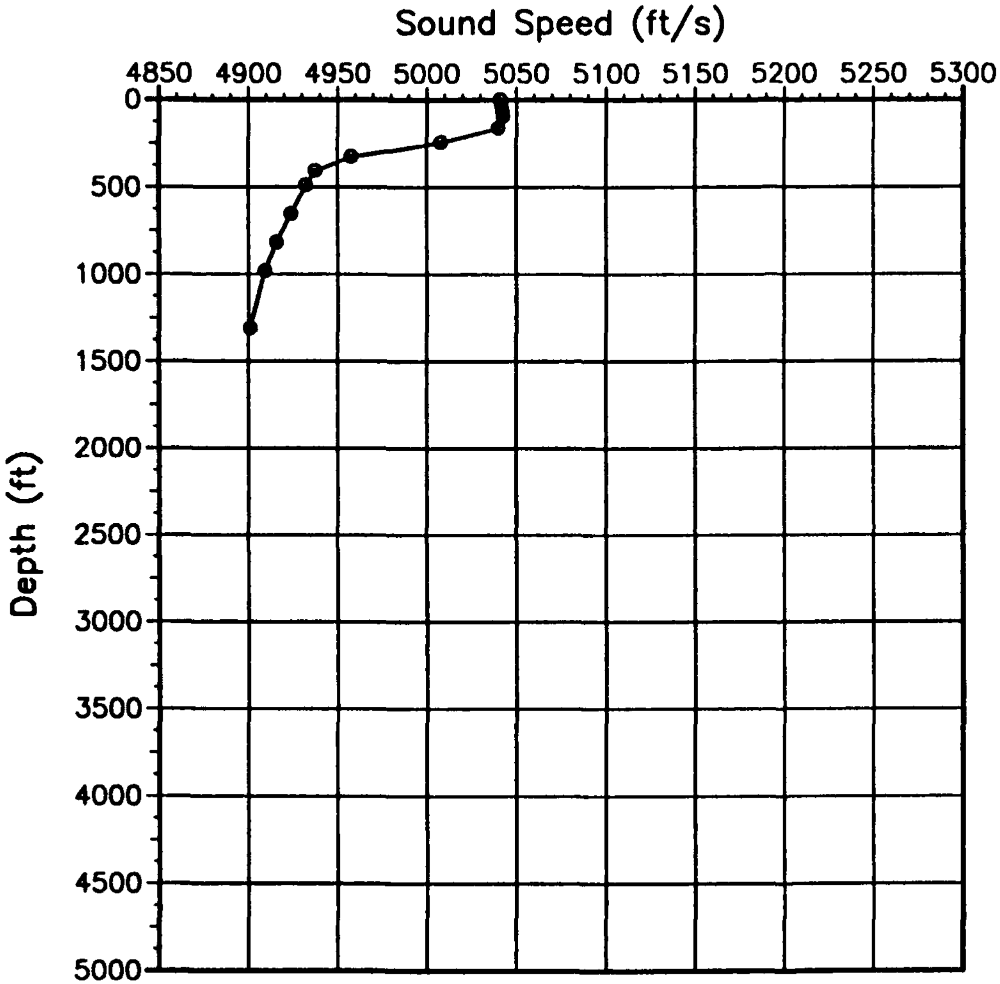
Depth (ft)	Speed (ft/s)
0.0	5051.5
32.8	5052.1
65.6	5052.9
98.4	5053.6
164.0	5054.9
246.1	5052.3
328.1	5033.8
410.1	4997.0
492.1	4966.5
656.2	4943.6
820.2	4923.8
984.3	4906.3
1312.3	4886.5

GDEM Sound Velocity Profile

SVP 14

Figure A33. Sound Velocity Profile Type 14

TRW Acoustic Baseline



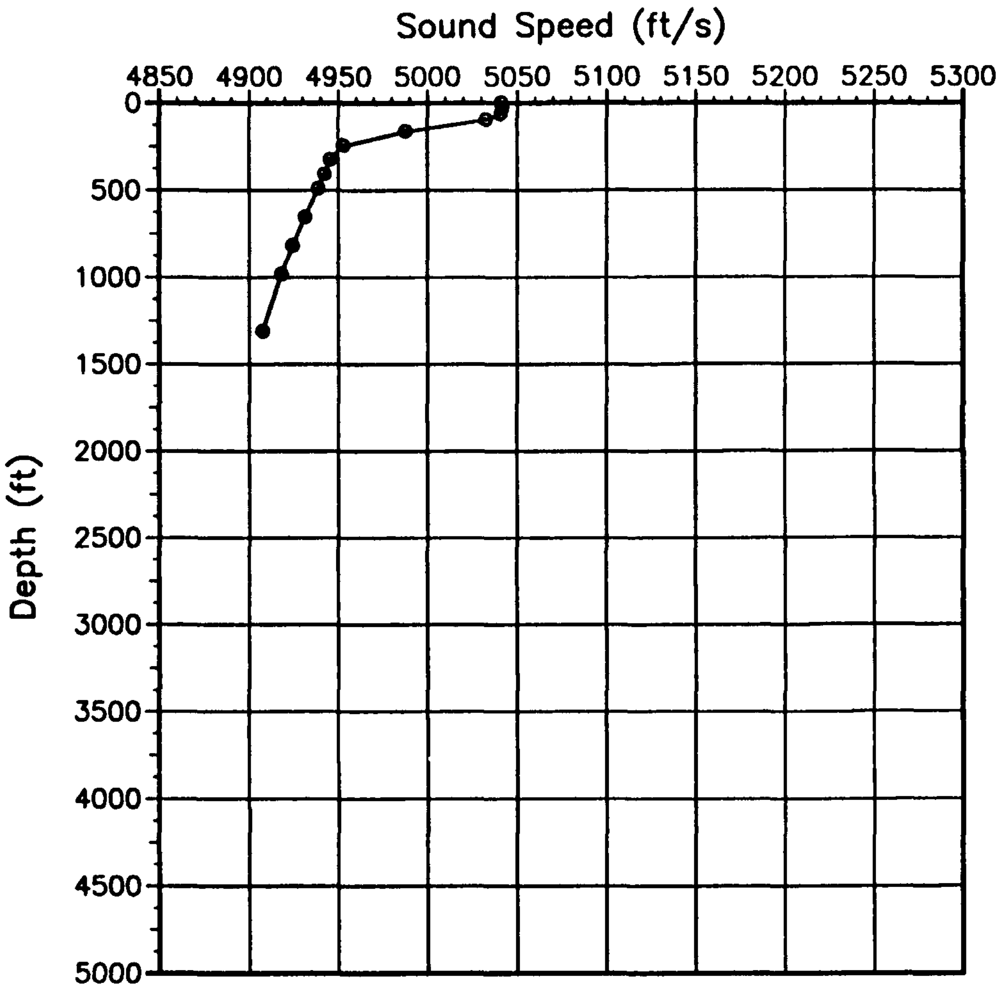
Depth (ft)	Speed (ft/s)
0.0	5040.8
32.8	5041.4
65.6	5042.0
98.4	5042.3
164.0	5039.5
246.1	5007.7
328.1	4957.5
410.1	4937.2
492.1	4932.0
656.2	4923.7
820.2	4915.5
984.3	4909.0
1312.3	4900.8

GDEM Sound Velocity Profile

SVP 15

Figure A34. Sound Velocity Profile Type 15

TRW Acoustic Baseline



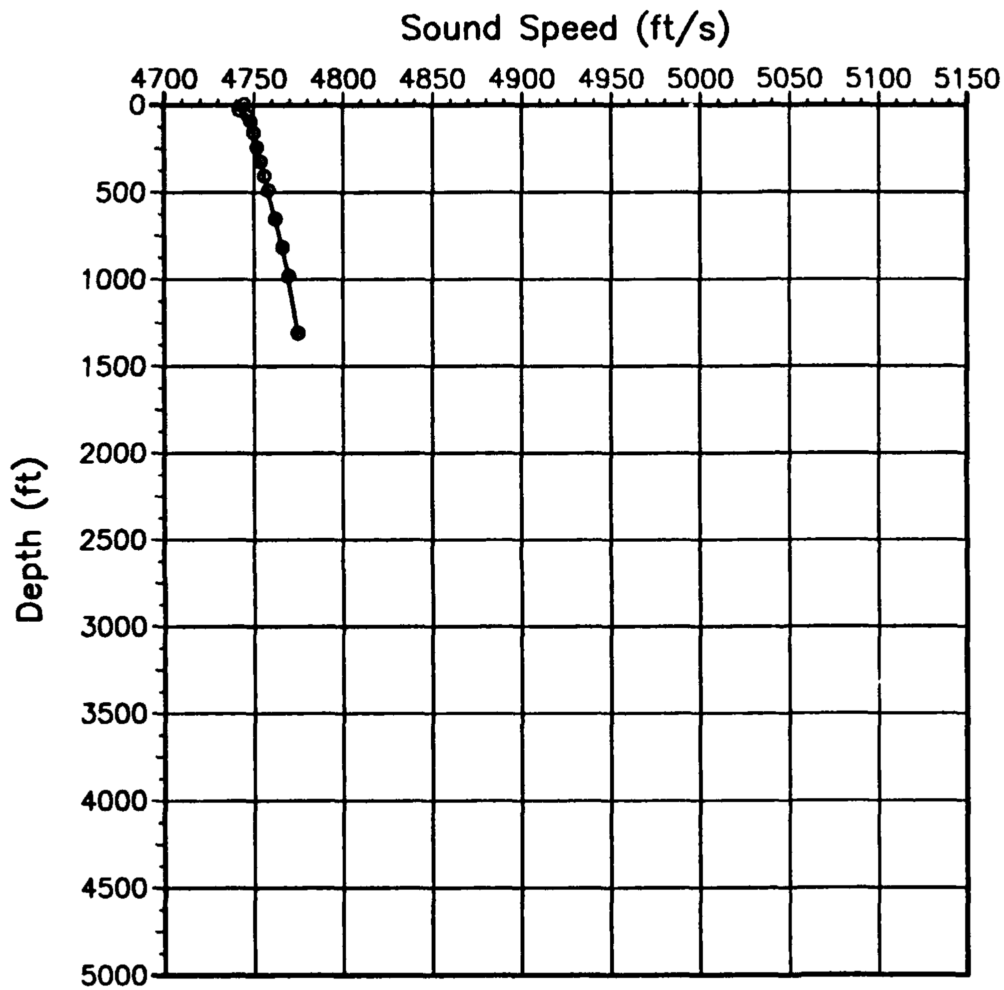
Depth (ft)	Speed (ft/s)
0.0	5040.8
32.8	5041.4
65.6	5040.5
98.4	5032.5
164.0	4987.6
246.1	4952.6
328.1	4945.2
410.1	4942.1
492.1	4938.6
656.2	4931.1
820.2	4924.0
984.3	4918.1
1312.3	4907.3

GDEM Sound Velocity Profile

SVP 16

Figure A35. Sound Velocity Profile Type 16

TRW Acoustic Baseline



Depth (ft)	Speed (ft/s)
0.0	4744.5
32.8	4741.8
65.6	4746.6
98.4	4748.0
164.0	4749.7
246.1	4751.4
328.1	4753.5
410.1	4755.6
492.1	4757.8
656.2	4761.9
820.2	4765.8
984.3	4769.1
1312.3	4774.4

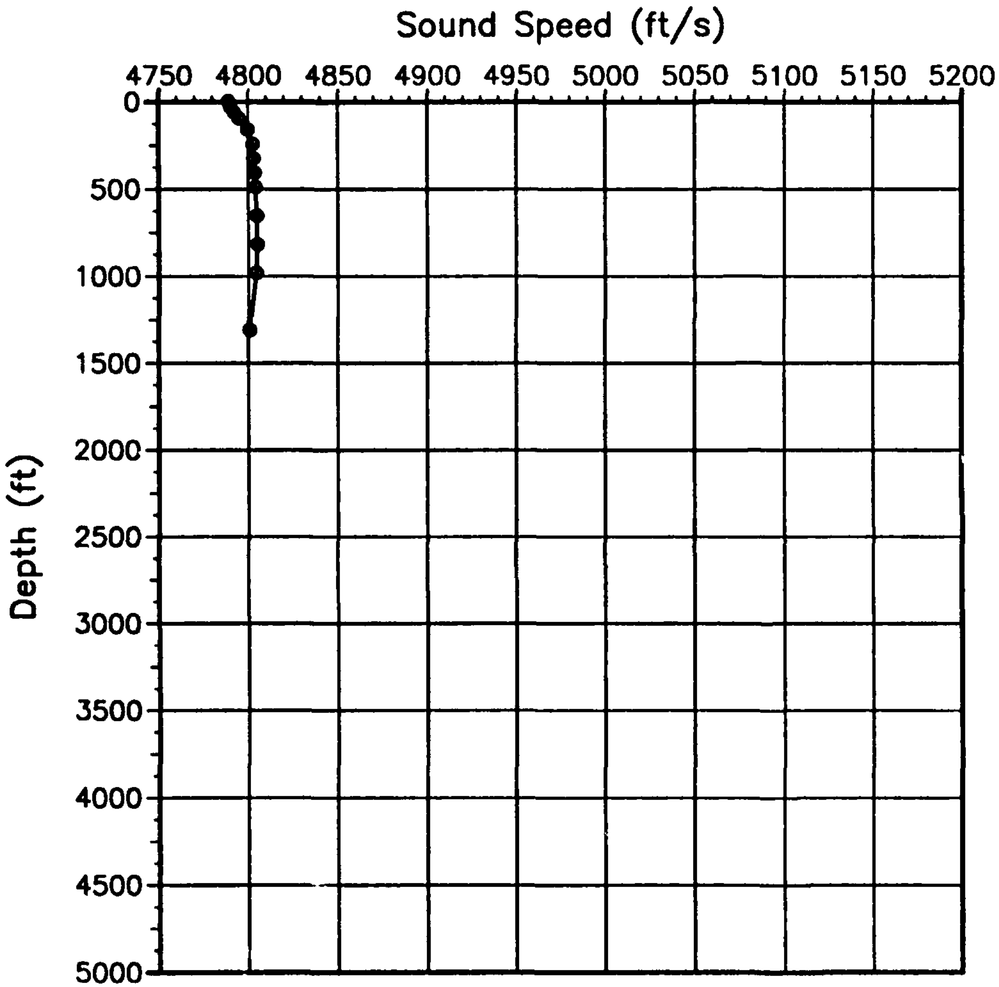
GDEM Sound Velocity Profile

SVP 17

Figure A36. Sound Velocity Profile Type 17

TRW Acoustic Baseline

23-MAR-92 14:08:52

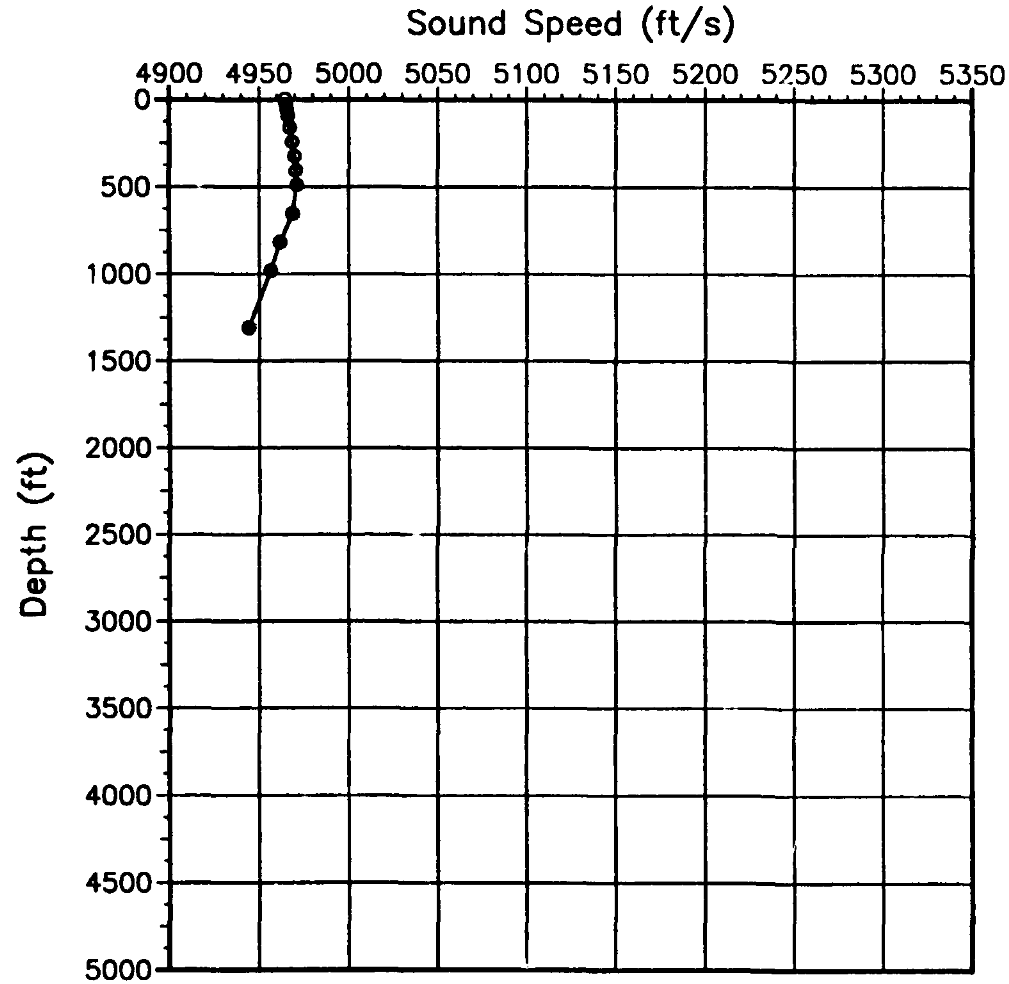


Depth (ft)	Speed (ft/s)
0.0	4789.0
32.8	4790.2
65.6	4792.3
98.4	4794.8
164.0	4799.7
246.1	4802.5
328.1	4803.1
410.1	4803.6
492.1	4804.1
656.2	4804.8
820.2	4805.1
984.3	4804.4
1312.3	4800.8

GDEM Sound Velocity Profile

SVP 18

Figure A37. Sound Velocity Profile Type 18



Depth (ft)	Speed (ft/s)
0.0	4964.3
32.8	4964.9
65.6	4965.4
98.4	4965.9
164.0	4967.0
246.1	4968.3
328.1	4969.6
410.1	4970.5
492.1	4971.1
656.2	4968.6
820.2	4961.5
984.3	4956.3
1312.3	4943.9

GDEM Sound Velocity Profile

SVP 19

Figure A38. Sound Velocity Profile Type 19

A4. SEDIMENT THICKNESS

Sediment thickness is a parameter extracted form the LFBL data base in the same manner as the geoacoustic parameters. Sediment thickness is represented by sediment two way travel time. Reference 3 provided a source of possible sediment thickness changes that can occur in shallow water ocean environments. The artificial data base was implemented in the same way as the SVP and BLUG artificial data base implementation. Table A1 gives the 19 sediment two way travel times used in this study.

Number	TWT Time (sec)	Number	TWT Time (sec)
1	.5	11	4.2
2	.7	12	6.7
3	.8	13	7.9
4	1.1	14	8.2
5	1.3	15	9.3
6	1.8	16	14.
7	2.1	17	16.8
8	2.9	18	24.1
9	3.1	19	30.
10	3.3		

Table A1. Sediment Two Way Travel (TWT) Times Used in This Analysis

A.5 BOTTOM DEPTH

The bottom depth artificial data base was constructed differently than the previous three data bases described above. A cyclic type function across different resolution artificial data bases for bottom depth was not realistic. A cyclic function would result in a succession of one sided gradual hills with a sharp drop off at the top representing the point where the function would cycle back to the original bottom depth value for fine grids. The primary aim of the artificial bottom data base was to simulate the effects of a slope on the TL calculation. A different type of slope was represented for the three grids used in the bottom depth analysis (two, five, and ten nautical miles). Table A2 gives the bottom depth values used for the five and ten nautical mile grid. All of this data is fabricated, and is not derived from any source.

Number	Bottom Depth (m)	Number	Bottom Depth (m)
1	457.2	11	274.32
2	457.2	12	259.08
3	426.72	13	243.84
4	426.72	14	213.36
5	426.72	15	282.88
6	396.24	16	152.4
7	396.24	17	121.92
8	335.28	18	91.4
9	335.28	19	60.96
10	274.32	20	60.96

Table A2. Bottom Depth Values Used in This Analysis for the Five and Ten nautical mile Grids